GIO-99-129-TAR



Monticello Mill Tailings Site Operable Unit III

Interim Remedial Action Work Plan for Operable Unit III— **Surface Water and Ground Water**

Draft Final

November 1999



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U.S. Department of Energy

Grand Junction Office 2597 B¾ Road Grand Junction, CO 81503 NOV - 8 1999

Mr. Paul Mushovic Environmental Protection Agency, Region 8 Suite 500, Mail Stop 8HWM-FF 999 18th Street, Denver Place Denver, CO 80202-2466

Mr. David Bird State of Utah Department of Environmental Quality Division of Environmental Response and Remediation 168 North 1950 West Salt Lake City, UT 84116

Subject: Monticello Mill Tailings Site, Operable Unit III, Interim Remedial Action Work Plan

Dear Mr. Mushovic and Mr. Bird:

Enclosed are two copies each of the subject document. This version of the IRA Work Plan incorporates text previously submitted in the IRA Remedial Design/Remedial Action Work Plan with the May version of the IRA Work Plan. Additional tasks have also been added to cover those activities necessary to get OU III to a final Record of Decision.

The DOE looks forward to resolving any comments you have on the document and hopes that the document can be finalized in January.

If you have any questions, please contact me at (970) 248-7612.

Sincerely,

Donald R. Metzler

Technical/Project Manager

Enclosure (2)

cc w/o enclosure:
R. Plieness, DOE-GJO
M. Butherus, MACTEC-ERS
Project File MSG 2.2.1 (J. Glasgow)

Monticello Mill Tailings Site

Operable Unit III

Interim Remedial Action Work Plan for Operable Unit III-Surface Water and Ground Water

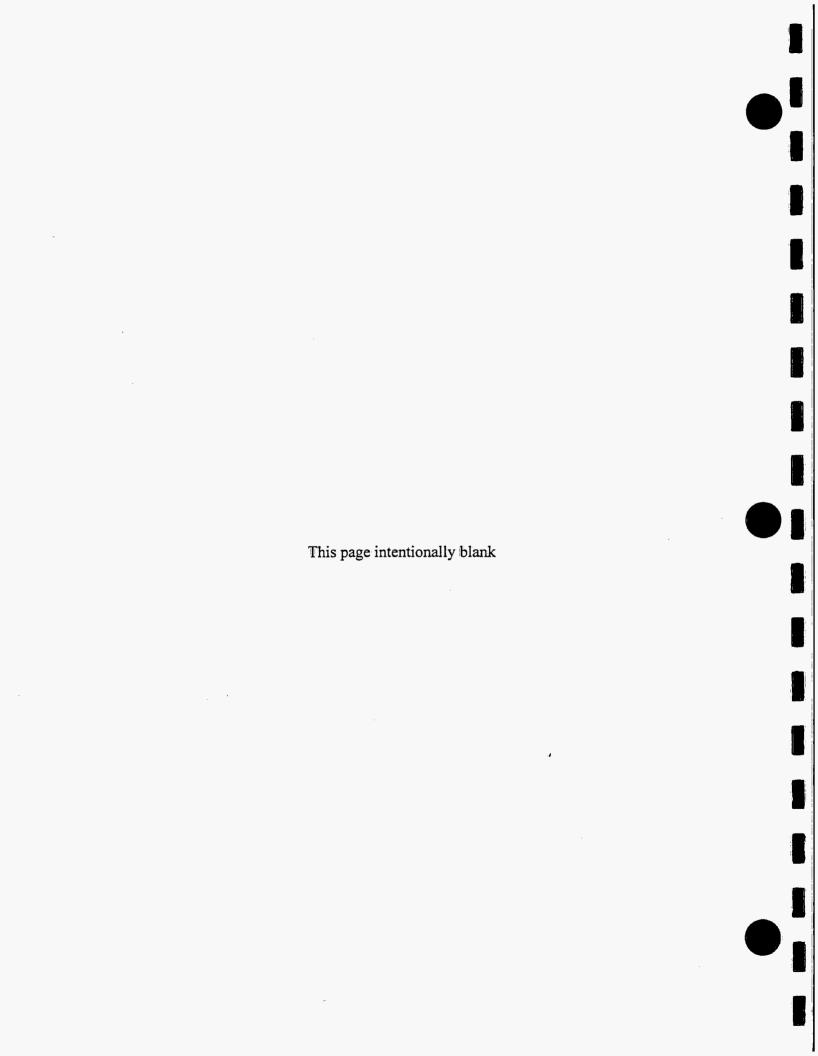
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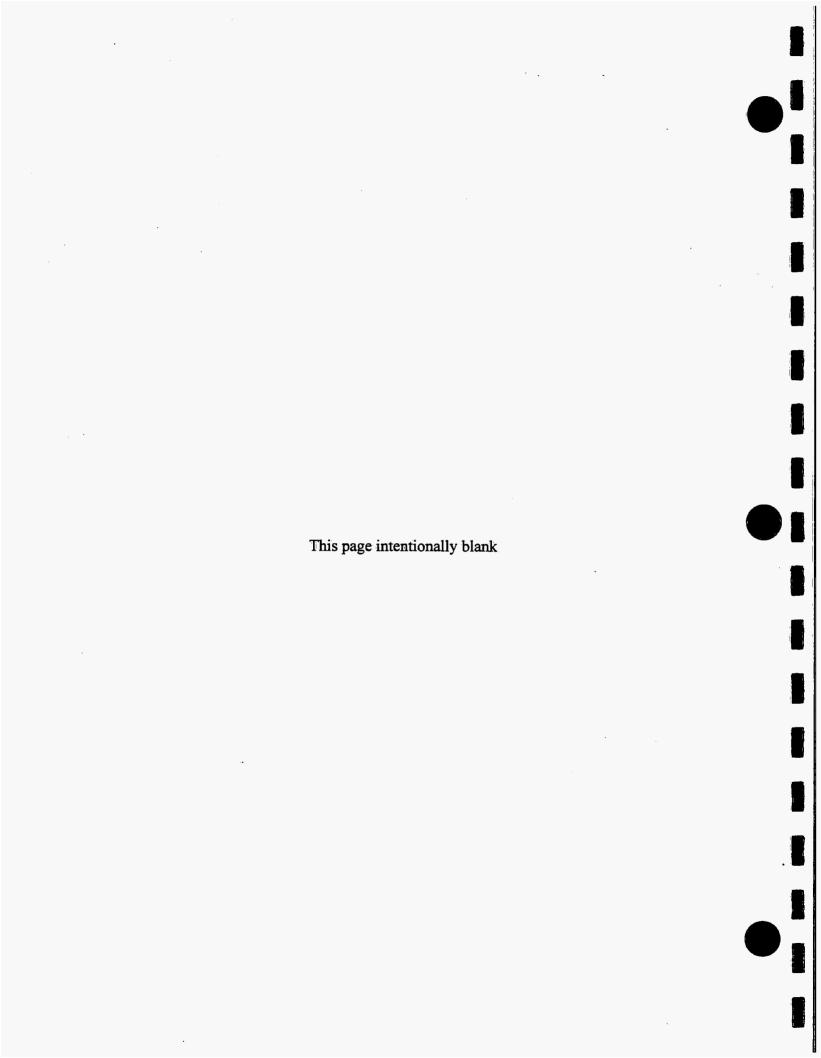
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Acronyms

AL Albuquerque Operations Office

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act

cm3/min centimeters per minute
cm/sec centimeters per second
cm/yr centimeters per year
COC contaminant of concern
DOE U.S. Department of Energy

EPA U.S. Environmental Protection Agency

FFA Federal Facilities Agreement

FS feasibility study

ft feet

FY fiscal year g/L grams per liter

GJO Grand Junction Office gpm gallons per minute HQ Headquarters

IRA Interim Remedial Action

IROD Record of Decision for an Interim Remedial Action

Kd distribution coefficient

kg kilograms

mg/L milligrams per liter

mL milliliters

MMTS Monticello Mill Tailings Site NTU nephelometric turbidity unit

OU Operable Unit

PeRT Permeable Reactive Treatment

RA Remedial Action

RAC Remedial Action Contractor

RD Remedial Design
RI Remedial investigation

SARA Superfund Amendments and Reauthorization Act

μg/L micrograms per liter

UDEQ Utah Department of Environmental Quality

ZVI zero-valent iron

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Executive Summary

This Operable Unit III Interim Remedial Action Work Plan gives an overview of management, tasks, and schedule for completion of the interim remedial action for Operable Unit III—Surface Water and Ground Water of the Monticello Mill Tailings Site. The major components of the interim remedial action which lead to preparation of the Operable Unit III record of decision are:

- Implementation of institutional controls,
- Millsite dewatering and treatment,
- Ground-water and surface-water monitoring,
- Data collection activities,
- Permeable Reactive Treatment (PeRT) Wall Treatability Study,
- Ground Water Modeling and Evaluation,
- Risk Evaluations,
- Preparation of an addendum to the Remedial Investigation, and
- Preparation of the post-Millsite Remediation Feasibility Study for Operable Unit III Surface Water and Ground Water.

Detailed scope and scheduling information and a discussion of progress made to date is given for each of the tasks. Following finalization of the post-Millsite Remediation Feasibility Study, a proposed plan will be prepared and public comment sought. Submittal of the draft final Record of Decision for Operable Unit III, a stipulated penalty milestone, is scheduled for May 15, 2005.

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1.0 Introduction

This Operable Unit (OU) III Surface Water and Ground Water Interim Remedial Action Work Plan identifies the activities necessary to implement the interim remedial action (IRA) for OU III at the Monticello Mill Tailings Site (MMTS) (Figure 1–1) in response to the Record of Decision for an Interim Remedial Action at the Monticello Mill Tailings Site, Operable Unit III – Surface Water and Ground Water (the IROD) (DOE 1998a). This IRA Work Plan also identifies the approach and activities necessary to select a final remedy for OU III and to document that decision in a record of decision (ROD).

The MMTS is on the National Priorities List and is being remediated in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. The U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), and the State of Utah entered into a Federal Facilities Agreement (FFA) pursuant to Section 120 of CERCLA/SARA, in December 1988 (DOE 1988). DOE, EPA, and the Utah Department of Environmental Quality (UDEQ) have agreed to perform response actions at the MMTS in accordance with the FFA. DOE is the lead agency that provides principal staff and resources to plan and implement the response actions. EPA and UDEQ share responsibility for oversight of activities performed under the FFA. EPA is the lead agency with ultimate responsibility and authority but shares its decision-making with UDEQ (DOE 1988, Section VIII.B).

The Monticello Site Management Plan (DOE 1998b) provides an overview of the site background and history, management structure, roles, and responsibilities, descriptions of OUs I, II, and III and the Monticello Vicinity Property project and their interrelationships, and an overall schedule for completion of remedial investigation and remedial action for the Monticello Projects. The Site Management Plan lists stipulated penalty milestones for the Monticello Projects which are enforceable milestones unless superseded by revised schedules agreed to by EPA, UDEQ, and DOE. The original document was finalized in March 1995 and the first revision was finalized in July 1998. The second revision to the Site Management Plan is currently in progress.

1.1 Overview of OU III Activities Completed to Date

When the remedial investigation (RI) began for OU III in November 1992, OU III consisted of contaminated surface water and ground water at and downgradient of the former Millsite and contaminated soil and sediment deposited downstream of the Millsite along Montezuma Creek. The OU III soil and sediment area began approximately 0.5 mile east of the eastern Millsite boundary and extended downstream along Montezuma Creek approximately 14,000 feet. The RI was finalized in September 1998 (DOE 1998c) and contains detailed information on the site description and history, site characterization activities, ground water fate and transport (ground water modeling) along with the baseline risk assessment.

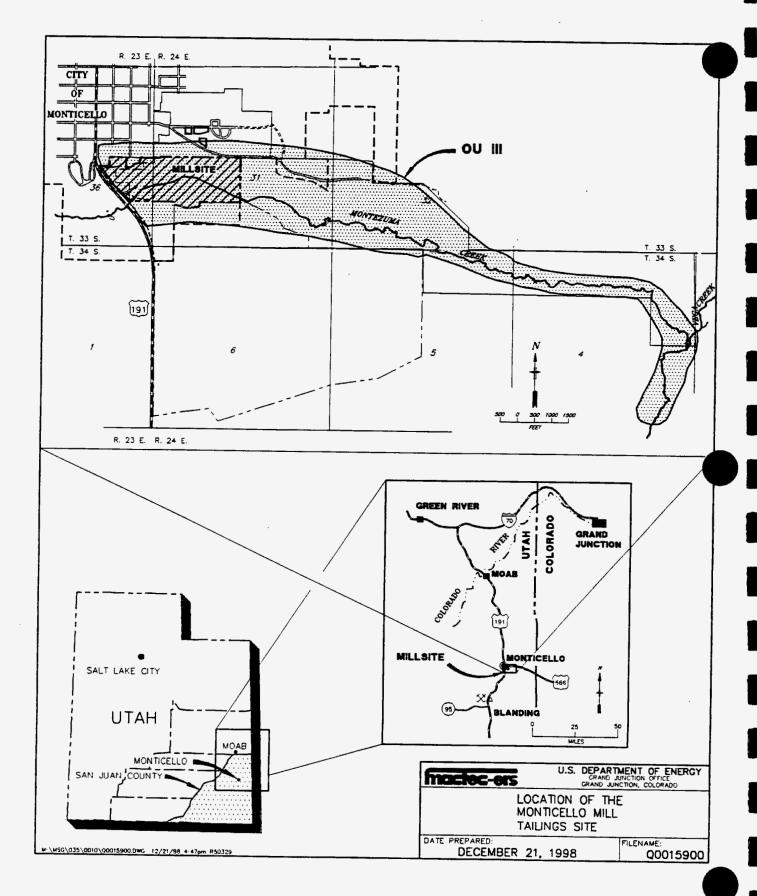


Figure 1-1. Location of the Monticello Mill Tailings Site

During preparation of the OU III RI, it was decided to separate analysis of the remedial alternatives for soil and sediment from those for surface water and ground water so that a decision on soil and sediment cleanup could be reached prior to closure of the repository designed for contaminated material from OUs I and II. An Alternative Analysis (DOE 1998) was prepared for soil and sediment that satisfied the requirements of an Engineering Evaluation/Cost Analysis. After a 30-day public comment period and a public meeting on April 7, 1998, DOE decided to pursue OU III soil and sediment cleanup as a non-time critical removal action and apply supplemental standards (remediation with alternative action levels) and institutional controls as the removal action. DOE documented the decision to pursue a non-time critical removal action in an Action Memorandum (DOE 1998d).

Subsequent to the remediation, a decision was made to address the final remedy selection for the OU III soil and sediment area under OU II of the MMTS. The Application for Supplemental Standards for Upper, Middle, and Lower Montezuma Creek (DOE 1999a) was prepared and approved by the regulatory agencies on July 1, 1999. Restoration activities on the soil and sediment properties were completed on July 27, 1999.

During review of the draft Monticello Mill Tailings Site, Operable Unit III Feasibility Study of Surface Water and Groundwater (DOE 1998e), it was recognized by DOE, EPA, and UDEQ that it was not possible at that time to definitively predict the effects that remediation of the Millsite and soil and sediment along Montezuma Creek will have on surface water and ground water. A decision was made to conduct an IRA and revise the draft FS after post-Millsite remediation conditions in ground water and surface water had stabilized. DOE proposed a preferred IRA in the Interim Remedial Action Proposed Plan for Surface and Ground Water Remedial Action Project (DOE 1998f) which was subject to a 30-day public comment period; DOE held a public meeting on April 7, 1998. After receiving public comment on the proposed plan, DOE drafted the IROD, which was signed by all parties on September 29, 1998. The components of the IRA addressed in the IROD are to

- implement institutional controls to prohibit use of contaminated alluvial ground water,
- extract and treat ground water during excavation and dewatering of the Millsite,
- acquire data on post remediation Millsite conditions to support future ground water modeling for further alternative analysis,
- conduct surface water and ground water monitoring to better understand the effects of Millsite remediation on water quality, and
- o conduct a Permeable Reactive Treatment (PeRT) Wall treatability study.

In addition to the IRA components specified in the IROD, in order to reach a ROD for OU III, DOE must

 prepare an addendum to the RI discussing data collection activities during the IRA, presenting a calibrated post-Millsite remediation ground water flow and transport model, and evaluating the baseline risk assessment presented in the 1998 RI using exposure point concentrations determined during the IRA and recent toxicity benchmarks,

- prepare a post-Millsite remediation FS, and
- prepare a proposed plan and hold a public comment period and public meeting on that plan.

Also during the IRA, there will be site inspections, yearly evaluations of applicable or relevant and appropriate requirements, and one of the CERCLA 5-year reviews.

1.2 Document History and Objective

The first draft of this Work Plan was titled Interim Remedial Design/Remedial Action (RD/RA) Work Plan for Operable Unit III – Surface Water and Ground Water and was prepared in November 1998 and revised in March 1999. The scope of the draft RD/RA Work Plan is generally based on the draft EPA guidance document Remedial Design and Remedial Action Guidance for EPA Oversight at Federal Facilities (EPA 1993). The draft RD/RD Work Plan refers to sampling and analysis plans that would be prepared to cover the details of the data collection efforts during the IRA.

The first sampling and analysis plan was prepared in November 1998 and was titled *Interim Remedial Action, Sampling and Analysis Plan, Phase I* (DOE 1998g). This first plan focused on vadose zone data collection activities. The second plan was prepared in May 1999 and was titled *Interim Remedial Action Work Plan* (DOE 1999b). The May 1999 IRA Work Plan combined the vadose zone data collection activities with saturated zone characterization activities. After reviewing the documents in August 1999, DOE, EPA, and UDEQ mutually agreed to revise the IRA Work Plan to include key sections from the RD/RA Work Plan and to include major activities on the path to an OU III ROD. This draft document is the result of the effort to combine the March 1999 RD/RD Work Plan with the IRA Work Plan.

The objective of this IRA Work Plan is to discuss the activities necessary to reach a final record of decision for OU III surface water and ground water. Many of the activities listed in this IRA Work Plan have been initiated; some of the activities are nearly complete. For this reason, after presenting the DOE project management structure in Section 2.0, the major activities in the OU III IRA that will be necessary to reach a ROD are described in Sections 3.0 through 9.0 along with a brief status of the progress made to date. A schedule for future activities is presented in Section 10.

1.3 Related Documents

The following documents provide additional background information and detailed information related to the tasks described in this work plan.

Programmatic Documents

- Monticello Site Management Plan (DOE 1998b)
- Monticello Projects Health and Safety Plan (DOE 1997a)
- Community Relations Plan (DOE 1998h)

Monticello Projects Quality Assurance Program Plan (DOE 1996)

Surface Water and Ground Water Documents

- Monticello Mill Tailings Site, Operable Unit III Remedial Investigation (DOE 1998c)
- Monticello Mill Tailings Site, Operable Unit III Feasibility Study of Surface Water and Groundwater (DOE 1998e)
- Monticello Mill Tailing Site, Operable Unit III, Proposed Plan (DOE 1998f)
- Monticello Mill Tailings Site, Operable Unit III, Interim Remedial Action Surface Water and Ground Water Monitoring Plan (IRA Monitoring Plan) (DOE 1999c)
- Record of Decision for an Interim Remedial Action at the Monticello Mill Tailings Site,
 Operable Unit III—Surface Water and Ground Water, Monticello, Utah. (DOE 1998a)

PeRT Wall Documents

- Deployment Plan for the Permeable Reactive Treatment Wall for Radionuclides and Metals (DOE 1997b)
- Design Specifications for the Monticello Millsite PeRT Wall Demonstration Project (DOE 1998i)
- Permeable Reactive Treatment (PeRT) Wall, Characterization Report (DOE 1998j)
- Permeable Reactive Treatment (PeRT) Wall, Results of Field Treatability Studies for the Monticello, Utah, PeRT Wall (DOE 1998k)
- Permeable Reactive Treatment (PeRT) Wall Project, Monitoring Well Network Design for the Monticello Millsite PeRT Wall Groundwater Treatment System (DOE 19981)
- "Results of Preliminary Groundwater Flow Models for Baseline and Various Permeable Reactive Treatment (PeRT) Wall Configurations at Monticello, Utah" (Cromwell 1998)

Soil and Sediment Documents

- Monticello Mill Tailings Site, Operable Unit III Remedial Investigation (DOE 1998c)
- Monticello Mill Tailings Site, Operable Unit III, Alternatives Analysis of Soil and Sediment (DOE 1998m)
- Action Memorandum Monticello Mill Tailings Site, Operable Unit III, Action Memorandum (DOE 1998d)
- Monticello Mill Tailings Site, Operable Unit III, Upper Montezuma Creek DOE ID Nos. MG-00951-VL, MG-00990-CS, MG-01026-VL, MG-01033-VL, and MG-01084-VL Removal Action Design (DOE 1998n)

- Monticello Mill Tailings Site, Operable Unit III, Lower Montezuma Creek DOE ID Nos. MG-01028-VL, MG-01029-VL, MG-01030-VL, Removal Action Design (DOE 19980)
- Application for Supplemental Standards Monticello Mill Tailings Site, Operable Unit III, Application for Supplemental Standards for Upper, Middle, and Lower Montezuma Creek (DOE 1999a)

2.0 Project Management Structure

DOE, EPA and State responsibilities for completion of the Monticello Projects is discussed in the *Monticello Site Management Plan* (DOE 1998b); the roles and responsibilities of the DOE Management Team and their contractor are discussed below.

2.1 DOE Management Team

The DOE Management Team is comprised of DOE Albuquerque Operations (DOE-AL), DOE Headquarters (DOE-HQ), and the DOE Grand Junction Office (DOE-GJO). The relationship between the offices is described in the Site Management Plan and shown on Figure 2.1–1.

The following Project Managers have been assigned by DOE with responsibility for OU III:

- Lead Project Manager who is responsible for overall project integration, daily project
 coordination, and is assigned the responsibilities of the Project Coordinator. The Project
 Coordinator is the formal GJO point of contact for EPA, the State, and DOE-HQ for the
 Monticello Projects.
- OU III Project Manager who manages the remediation of soil and sediment on OU III
 peripheral properties, the surface-water and ground-water IRA, and preparation of surfacewater and ground-water decision documents.

The GJO has also assigned matrix support for procurement, public affairs, health and safety and environmental compliance to the Monticello Projects. The Office of Chief Counsel at DOE-AL is the legal advisor to the projects. Financial, procurement, and real estate management assistance and support are also provided by DOE-AL.

2.2 Remedial Action Contractor Management Structure

The DOE-GJO has contracted with a remedial action contractor (RAC) for technical assistance. The RAC is responsible for ensuring that all remedial activities are executed in compliance with FFA, regulatory, and health and safety requirements. The RAC Program Manager reports directly to the DOE-GJO Project Managers and has the ultimate responsibility for implementing the project scope and schedule defined by the DOE Project Managers.

The RAC has assigned a Project Manager to OU III who reports to the Program Manager and is responsible for the day-to-day implementation and management of the project as directed by the DOE–GJO Monticello Project Coordinator. Neither the Program Manager, nor any other RAC personnel, has authority to speak for DOE on project direction, schedule, issues, or policy.

Together, the DOE Project Managers and the RAC Program Manager and Project Manager form a team that with EPA and UDEQ support, are dedicated to reaching final remedy selection for OU III. DOE intends to have quarterly meetings with EPA and UDEQ during which results of the IRA data gathering efforts and the technical aspects of the project are discussed.

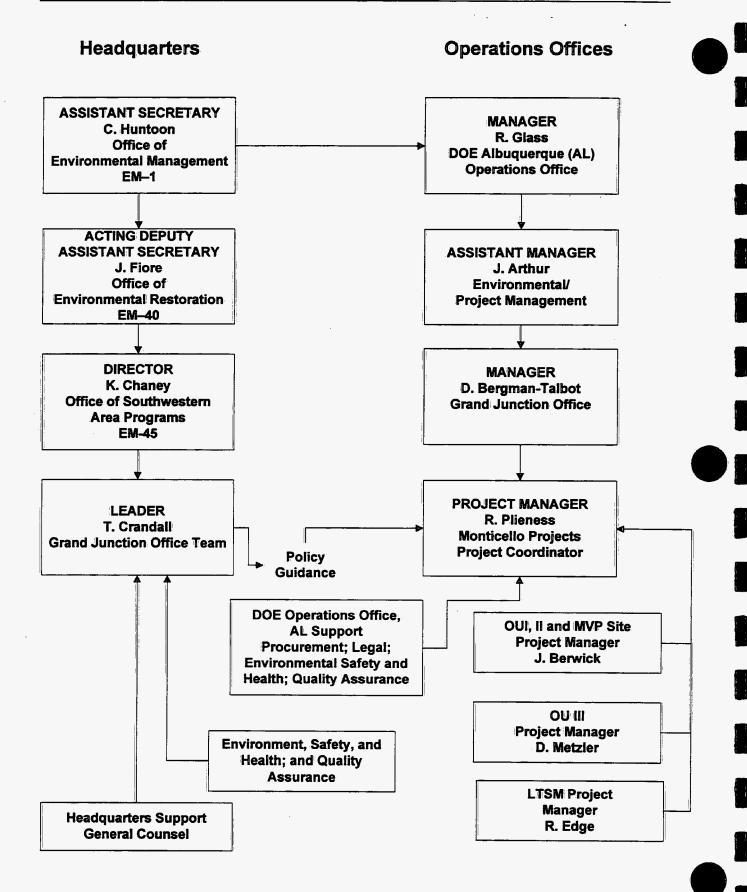


Figure 2.1-1. DOE Project Management Structure

3.0 Institutional Controls

The purpose of implementing institutional controls on alluvial ground water is to prevent use of the contaminated ground water (and thereby control risk from exposure) until such time when the water quality has been determined to be acceptable. DOE submitted a letter of request and justification for institutional controls on the contaminated alluvial aquifer along Montezuma Creek to the Utah State Engineer's Office on July 9, 1998. The Utah State Engineer's Office informally approved DOE's request for institutional controls for the alluvial aquifer on October 21, 1998. At that time the State Engineer's office assumed responsibility for preparation of a ground-water management policy, for fulfilling the public participation requirements associated with the implementation of institutional controls, and for implementing the institutional controls.

On March 18, 1999, the State Engineer issued notice of a public meeting on April 7, 1999 and a 30-day public comment period. The State Engineer's office did not receive comments during the public comment period. At the close of the public comment period the Ground-Water Management Policy for the Monticello Mill Tailings Site and Adjacent Areas (a copy is provided in Appendix A) was issued and became effective May 21, 1999. The policy states that new applications to appropriate water for domestic use from the alluvial aquifer within the boundaries of the Monticello Ground Water Restricted Area will not be approved. A map of the Monticello Ground-Water Restricted Area is attached to the Ground-Water Management Policy.

Included in the Ground-Water Restricted Area are some areas of DOE-owned property. DOE is currently pursuing transferring four of these properties (MS-00893, MP-00181, MP-00391-VL, and MP-01077-VL) to the city of Monticello under the Federal Lands to Parks Program. Transfer to the city is expected to be completed by early in the year 2000. Use of alluvial aquifer ground water will be limited by means of deed restrictions placed on those properties. One other piece of DOE-owned land is anticipated to be sold to a private entity (MS-01081-VL). Deed restrictions will also limit the use of alluvial ground water for this property.

The State Engineer's Office conducted a search of their database for existing water rights appropriating water for domestic use. Only one such water right, Water Right 09-0130, exists within the Monticello Ground-Water Restricted Area. The water right is to 0.01 cubic foot per second of flow from a surface diversion of an unnamed spring. A field visit to the location of the water right was made on April 7, 1999. Water appears to have been taken from a very shallow well or pumped from a sump to supply what are now the remains of a house nearby. The property owner has been contacted about relinquishing the water right. Currently, the U.S. Army Corps of Engineers is preparing a property appraisal and a restrictive easement that will include the water right and restrictions placed on land use because of contamination remaining in the soils and sediments along the creek. The U.S. Army Corps of Engineers will present the restrictive easement to the property owner along with an offer for purchase of the restrictive easement during Fall 1999.

DOE has committed to ensuring that the institutional controls are working. DOE will conduct annual inspections of the properties to look for any evidence of well installations or ground water use. The first inspection occurred during October 1999 and no suspected use was encountered. The institutional controls will remain in place at least until the final record of decision for OU III is developed. The need to continue institutional controls will be reevaluated at that time. It is

anticipated that institutional controls will remain in place after the final record of decision for OU III is signed. The results of the annual inspections and a determination as to whether the institutional controls are protective of human health will be evaluated and documented in the CERCLA 5-Year Review reports. The next CERCLA 5-Year Review report will be submitted in February 2002.

4.0 Millsite Dewatering and Treatment

The primary objective of Millsite dewatering and treatment was to facilitate excavation and removal of mill tailings and contaminated soil that extended below the water table. It was also realized that in treating contaminated ground water, contaminants would be permanently removed from the ground water system, thereby, positively affecting ground water and surface water quality.

Ground water removal at the Millsite was initiated in March 1998 with construction of a dewatering trench along the western side of the Carbonate Pile. Up to 100 gallons per minute entered the trench and flowed to Pond 3. In May 1998, an "L" shaped trench was constructed along the west and south sides of the Carbonate Pile. The trenches extended to bedrock and thus intercepted all alluvial ground water. Water was pumped from the trenches to allow remediation of the Carbonate Pile. On occasion, dewatering was halted due to insufficient capacity at Pond 3. The Carbonate Pile excavation eventually extended to bedrock. Uncontaminated ground water that discharged to the excavation from the west was then routed to Montezuma Creek to reduce the inflow to Pond 3 and reduce treatment volumes. As excavation progressed eastward to include the East Pile, very little ground water was encountered. Intercepting ground water from the west and pumping in the Carbonate Pile area contributed to the dry conditions in the East Pile.

Some of the water recovered was used for dust control; the rest was treated at the waste water treatment plant (WWTP) to Utah Pollutant Discharge Elimination System (UPDES) standards before discharge to Montezuma Creek or use for dust control. Prior to 1998, approximately 4 million gallons of water were treated at the site. In March 1998, a reverse osmosis system was added to the treatment process. The WWTP operated from April 1998 through the winter and in May 1999, the WWTP was dismantled. Since April 1998, the plant processed over 50 million gallons.

OU III involvement in dewatering and treatment activities was limited to acquisition of data on volumes and concentrations of water being removed from the surface water and ground water systems. Using this data, it is estimated that between about 50 and 100 kilograms (kg) of uranium were removed from (and as source to) the alluvial aquifer during dewatering and treatment. This assumes a total treatment volume of 54 million gallons of water with uranium concentrations averaging between 0.5 and 1 mg/L (see Appendix B for calculation methods). This can be compared to a mass of 1,800 kg uranium (dissolved and sorbed) that was estimated to be present in the alluvial aquifer prior to Millsite remediation (see Appendix C, Calculation Q00076AA). The uranium removed from the alluvial system during approximately one year of continuous ground water treatment is therefore approximately 3 to 6 percent of the total inventory. This excludes the mass of sorbed uranium that was excavated and removed from the system during surface remediation. As the estimates in Appendix C indicate (Calculation Q00076AA), the contribution of the sorbed phase to the total mass inventory is much greater than the solute phase, even if the Kd is only 1 mL/g (uranium example). All calculations included in Appendix C are taken from the draft FS (DOE 1998c).

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5.0 Data Collection Tasks

The overall goals of data collection tasks are to obtain the information necessary to revise the hydrological conceptual site model and in turn, refine the ground water flow and transport model for the site. Tasks will be implemented to 1) characterize the distribution and mobility of contaminants in the sub-pile vadose zone of the remediated Millsite, 2) characterize contaminant distribution and flow conditions in surface water and ground water after Millsite remediation, and 3) evaluate contaminant mobility in the aquifer. Information obtained by these tasks will be used to evaluate remedial alternatives in the revised FS that will be completed in 2004 and support selection of the final remedial alternative. In addition, data will be collected to evaluate the PeRT wall as a treatment technology. Data collection for the PeRT wall treatability study are addressed separately in Section 6.0.

5.1 Background

The ground-water flow and contaminant transport models documented in the RI (DOE 1998c) and draft FS (DOE 1998e) were based on hydrologic conditions and contaminant distributions in ground water that existed prior to Millsite remediation. Surface-water flow, ground-water flow, and contaminant distributions have been significantly altered from pre-remediation conditions. For example, dewatering and treatment, and excavation of aquifer material in the contaminant plume during remediation has removed source from the saturated zone. Source removal from the saturated zone was not represented in the RI and FS models.

The RI models predicted that the vadose zone beneath the piles would remain a long-term source of ground water contamination after remediation to radiological standards. However, there was only a limited amount of site-specific data available to use in the initial prediction of the vadose zone source. Furthermore, the dimensions of the post-remediation vadose zone were unknown at the time and could only be approximated. As remediation proceeded, additional characterization data (see Section 5.2 and 5.3) became available and was used to guide soil removal beyond the depth of radiological contamination. In general, the data indicated that significant quantities of leachable uranium were present in sub-pile soil and that ground water quality could be adversely impacted.

The predictive models presented in the RI and draft FS may be further limited because the geochemical processes that influence contaminant transport in ground water and in the unsaturated zone at the site were not investigated in detail.

5.1.1 Specific Model Limitations and Data Gaps

The following conditions, as they apply specifically to the vadose zone, are identified as those having potential impact on the model predictions presented in the draft FS:

• The FS models assumed that all vadose zone source was removed. This assumption may be non-conservative based on the actual extent of surface remediation. Soil sample results obtained during verification were used to direct sub-pile soil removal 2 feet beyond the depth of radiological contamination in many areas of the Millsite. A large volume of potential

source material was removed as a result, and although this practice was extended over much of the sub-pile area, secondary sources areas remain on site.

- The vadose zone source term cannot be realistically estimated until the dimensions (area and thickness) of the sub-pile vadose zone are known. Land survey results of the verified surface of the Millsite, including area remediated to bedrock, will be made available through OU I activities. Post-remediation water-level measurements will complete the data requirements necessary to define the area and thickness of the sub-pile vadose zone.
- The concentrations of contaminants in vadose zone soil and soil water are unknown. The vadose zone source term cannot be realistically estimated without concentration data.
- The mobility of contaminants in the vadose zone has not been evaluated in detail for the site. The source term will be very sensitive to contaminant mobility. For example, a contaminant that is present in relatively high concentrations in soil but is immobile under the ambient geochemical conditions will not be a source of ground-water contamination. Conversely, changing geochemical conditions may mobilize the contaminant and thus contribute to ground-water contamination.
- The vadose zone source was estimated using areal recharge equivalent to about 6 percent of the mean annual precipitation for Monticello. The models were quite sensitive to the recharge rate in predicting contaminant flux and ground-water concentrations. Recharge was calculated to be approximately 0.1 centimeters per year (cm/yr), or 0.2 percent of the mean annual precipitation, using the chloride mass flux method and soil collected from dry farmed land about 1 mile south of the Millsite during a repository siting study. Recharge and contaminant mobilization may increase significantly if a golf course is built on the Millsite, as is currently anticipated.

The following conditions are identified as having potential impact on the model predictions presented in the draft FS as they apply to surface-water flow, ground-water flow, and contaminant distribution and mobility in the alluvial aquifer:

- The model predictions may be overly conservative with regard to the assumption of source remaining in the alluvial system. Prior to its disassembly in May 1999, over 50,000,000 gallons of contaminated water were collected and treated by the Waste Water Treatment Plant. Approximately 60 percent of the water treated was ground water.
- The areal extent of contaminated ground water and contaminant concentrations are unknown and cannot be defined until Millsite remediation is completed and the aquifer and creek are reconstructed. Excavation of radiological contamination extended to bedrock over much of the acreage at the Millsite, removing all aquifer materials. This also reduced the mass of contaminants in the aquifer.
- The geometry of the aquifer and Montezuma Creek may be different. Also the hydraulic conductivity of the alluvial aquifer may change from pre-remediation conditions in areas where significant amounts of backfill have been imported.

 The mobility of contaminants in the saturated zone has not been evaluated in detail for the site. This includes the need to determine if contaminant transport at the site can be described by reversible equilibrium-controlled sorption and to determine the chemical partitioning and leaching characteristics of the contaminants in the aquifer.

Specific data collection tasks, rationale, and data uses to address the above limitations in the RI and FS models are described in the following sections. The general approach is to first characterize the distribution of contamination in the sub-pile vadose zone, in ground water, and in surface water. Secondly, laboratory experiments will be conducted to evaluate contaminant leaching in the vadose zone and aquifer. Synthetic fluids will be used in the tests to represent various water compositions at the site that are (or may become) in contact with those materials. Additional work will include sampling and analysis of pore water in the vadose zone, sampling and analysis of saturated zone soils, conducting gradation and moisture tests on backfill materials, estimating surficial recharge on the Millsite, and conducting aquifer pumping tests.

5.2 Task 1: Characterize the Distribution of Metals in Vadose Zone Soil

Soil sample collection for analysis of metals has been an ongoing activity at the Millsite during verification of cleanup for OU I. The scope of the soil sampling has been expanded beyond the OU I verification plan so that results will characterize the lateral and vertical distribution of metal concentrations in vadose zone soil that remain after Millsite remediation.

5.2.1 Scope

The OU I verification plan (DOE 1997c) specifies the sampling and analysis requirements for characterizing metals in soil from 0 to 0.5 feet (ft) and 2 to 3 ft below the verified surface of the Millsite. A sample will be collected from approximately 330 verification grid cells from the 0 to 0.5 ft depth interval. At 68 of the 330 grid cells, samples will be collected from the 2 to 3 ft depth interval. Sampling locations include sub-pile and off-pile areas of the Millsite. Each sample will be analyzed for metals and pH.

At 28 of the 2-3 ft subsurface locations described above, soil samples will be collected from the 4-5 ft and 6-7 ft depth intervals. The subsurface sample locations are mainly in areas formerly overlain by the tailings piles and where remediation is not anticipated to extend to bedrock or below the water table. These areas are assumed to be of the greatest concern as potential sources of ground-water contamination. If excavation removes all of the sub-pile material at a location selected for depth sampling, a new location will be selected at a nearby grid block. The locations where samples will be collected for metals characterization from the surface and subsurface are shown in Plate 1. Table 5.2.1–1 lists the locations where subsurface samples will be collected. Additional detail regarding the selection criteria and representation of the subsurface sampling locations is provided in Appendix D, Comment 8.

Table 5.2.1-1. Subsurface Sampling Locations for Metals Characterization

	Grid Blocks Designated for 2-3 ft Depth Samples					
Grid	Former Pile Area	Grid	Former Pile Area	Grid	Former Pile Area	
1223	Off-Pile	3291	Acid	4220	East	
1447	Carbonate	3309	East	4458	East	
1845	Carbonate	3417	Vanadium	4466	East	
2037	Carbonate	3584	Acid	4719	Off-Pile	
2067	Carbonate	3588	Acid	4847	East	
2337	Carbonate	3710	East	4851	East	
2799	Vanadium	3636	East	5056	East	
2805	Vanadium	3947	East	5058	East	
2951	Acid	3964	Off-Pile	5193	East	
2994	Acid	3668	Off-Pile	5359	East	
3069	Acid	4062	Off-Pile	5317	East	
3084	Acid	4122	East	5400	East	
3146	Vanadium	4148	East	5507	Off-Pile	
3197	Acid					
	Grid Blocks De	signated	for 2-3, 4-5, and 6-7 ft	Depth Sa	mples	
1514	Carbonate	2919	Vanadium	3441	East	
1668	Carbonate	3022	Vanadium	3653	Acid	
1853	Carbonate	3051	Vanadium	3923	Off-Pile	
1880	Carbonate	3104	Acid	4644	East	
1975	Carbonate	3238	Vanadium	4359	East	
2041	Carbonate	3254	Acid	4775	East	
2153	Carbonate	3287	Acid	4384	Off-Pile	
2409	Carbonate	3339	Vanadium	4951	East	
2618	Vanadium	3395	Acid	5262	East	
2627	Carbonate					

As of August 27, 1999, 282 samples have been collected for metals characterization. As remediation proceeded, the surface and subsurface soil sample results were used in conjunction with column test results to guide soil removal beyond the depth of radiological contamination. This amounted to removing a 2-ft layer in separate areas of each former tailings pile, and a 4-ft layer along the toe of the former Vanadium Pile. After the respective layers were removed, a limited number of samples were collected from the new surfaces at the piles. Therefore, the number of samples from the final Millsite surface will be less than 330.

5.2.2 Field Sampling Procedures

The surface soil samples will be collected in accordance with the OU I verification plan (DOE 1997c). Each surface sample will be composited from 9 individual sampling locations within a given grid cell. The subsurface samples will be collected from a single location at the approximate center of the verification cell. Locations and depths of subsurface samples may change depending on field conditions. For example, if ground water or bedrock is encountered above the prescribed sampling interval, samples will be collected from shallower depths. When this occurs, the depth of sample collection and depth of bedrock or ground water will be documented in the field log.

Subsurface samples will be collected using hand augers or a rig mounted percussion driven core sampler. The core sampling may be conducted with or without plastic liners. If liners are used, each sample will be collected in a new liner. Soil samples for metals characterization will be placed in (1) 500 milliliters (mL) high density polyethylene bottle. All sample bottles will be new and precleaned in accordance with the U.S. Environmental Protection Agency (EPA) protocol in *Specifications and Guidance for Contaminant-Free Sample Containers* (EPA 1992). Additional bottles will be collected at some surface and subsurface locations for Task 2 objectives (see Section 5.3).

Visible soil will be removed from all downhole sampling equipment between sample collection at different depth intervals within a given grid cell to prevent cross-contamination. Visible soil will be removed and sampling tools will be decontaminated using potable water between grid cells. Clean disposable gloves and decontaminated tools will be used when transferring soil to the sample bottles.

Each sample will be identified by the grid cell number, a unique sample tracking number (sample ticket book number), and the depth interval of collection. Each depth interval will receive a separate sample number. If more than one sample bottle is collected from a given depth interval (see Section 5.3), each bottle will receive the same sample number. The sample identification information and all other sample collection information will be recorded in field logs, in the sample ticket book, on sample bottle labels and sample chain of sample forms. Samples will be delivered under chain of custody to the DOE Analytical Chemistry Laboratory (GJO Laboratory), Grand Junction, Colorado.

5.2.3 Laboratory Analysis

All surface and subsurface soil samples collected for metals characterization will be analyzed for arsenic, cobalt, copper, lead, lead-210, manganese, molybdenum, selenium, uranium (non-isotopic), vanadium, and zinc using standard EPA methods. Analysis of lead, molybdenum, and uranium is by inductively coupled plasma-mass spectrometry (ICP-MS) in accordance with the GJO Laboratory Standard Operating Procedure (SOP) AS-6. This is the laboratory's SOP for EPA SW-846 method 6020. The remaining analytes will be analyzed by inductively coupled plasma-atomic emission spectroscopy (ICP-AES). This is the laboratory's SOP for EPA Methods 200.7 CLP(M) and 6010A. The pH of each sample will also be measured at the laboratory using EPA Method 9045C. One bottle per sample number will be submitted to the GJO Laboratory for analysis of metals and pH. The remaining bottles per sample number (collected for Task 2 objectives) will be temporarily archived by the GJO Laboratory.

5.3 Task 2: Evaluate Contaminant Mobility in Vadose Zone Soil

Column tests will be performed to evaluate desorption behavior of arsenic, uranium, and vanadium from vadose zone soil. These analytes have been identified as the primary risk drivers in the RI (Appendix L, Human Health Risk Assessment) (DOE 1998c). In general, the column tests will consist of placing a soil sample into a cylindrical column and then passing a fluid of known composition (without contaminant species) through the soil at a known flow rate. The test fluids will be made in the laboratory to mimic the composition of specific waters at the site (see Section 5.3.2). The effluent is periodically monitored for contaminant species and other solution

parameters such as pH, alkalinity, Eh, and major ions. Test results will be summarized as breakthrough curves, in which the effluent concentration is plotted either as a function of time or the volume of fluid passed through the column. The curves will then be analyzed to evaluate desorption characteristics and contaminant retardation under the given test conditions.

Distribution coefficients (Kd) will be determined from the desorption curves by solving the retardation equation (see Freeze and Cherry, 1979; page 404). Alternatively, distribution coefficients may also be estimated using published sorption isotherm models (e.g., Freundlich sorption isotherm) and 1-dimensional flow and transport modeling to fit the observed breakthrough curves. Flow to some of the columns will be temporarily interrupted for several days to determine if desorption is kinetically controlled. This is intended only to provide qualitative information about processes that might affect transport at the site. The information will be important when using the Kd approach in predictive transport models. For example, if contaminant release is limited by a kinetic step, and desorption is not rapid and reversible as the Kd concept assumes, then predicted aquifer cleanup times may be underestimated.

Results of six column tests that have been completed are summarized in the IRA Annual Status Report for the period between September 1998 and June 1999 (DOE 1999d).

5.3.1 Geochemical Setting

This section summarizes the pH and alkalinity in environmental media at the site. These parameters have been identified as important controls on contaminant mobility. The geochemical setting is evaluated to define the current site conditions governing contaminant mobility and to develop scenarios that may potentially influence mobility under changing future conditions. Ambient conditions of pH in surface water, vadose zone soil (off-site and on-site), and vadose zone soil water are basic (pH >7). For example, the pH of all surface-water samples collected during the RI was between 7.3 and 8.4. Sub-pile and off-pile soil pH measured to date ranged between 7.5 and 8.3, and the pH of sub-pile pore water measured during 1992 was neutral to 7.8. Alluvial ground water is mildly acidic to neutral.

The approximate range of alkalinity in surface-water samples collected upgradient of the Millsite is 100 to 235 milligrams per liter (mg/L) as CaCO₃ (mean = 175 mg/L as CaCO₃). Surface water at these locations is approximately saturated with calcite. Similar values of alkalinity occur in surface water on and downgradient of the Millsite. The approximate range of alkalinity in upgradient ground water is 100 to 300 mg/L as CaCO₃ (mean = 250 mg/L), compared to values between 300 and 700 mg/L in sub-pile soil water and contaminated ground water on and downgradient of the Millsite.

Three precipitation samples (rain) collected in Grand Junction on October 22, 1998, contained 10 to 30 mg/L alkalinity as CaCO₃. Assuming that the rain water samples are representative of the Monticello area, the alkalinity of precipitation increases to the observed concentrations in upgradient surface water and ground water during infiltration and runoff (the alkalinity [and pH] of precipitation collected in Monticello will also be measured). Precipitation in eastern Utah is acidic, with an approximate pH range of 5.5 to 6.5 (Utah Climate Center 1998). In preliminary tests conducted at the GJO, the pH of distilled water rapidly increased from 7 to 8.5 when mixed with native vadose zone soil collected at the site. The result suggests that acidic precipitation falling on the site will rapidly become basic. The cause of the increase in pH is uncertain but is

likely due to equilibration with carbonate minerals. Since the point of zero charge is near pH 2 for most common silicate minerals, adsorption of protons to these minerals could also cause the pH to increase.

Preliminary batch-type tests performed by the Environmental Sciences Laboratory using sub-pile soil indicate that the Kd for uranium is very sensitive to the alkalinity of the fluid. For example, at alkalinities between approximately 25 and 200 mg/L as CaCO₃, Kd values for uranium ranged from 125 mL/g to 5.2 mL/g, respectively. Contaminant mobility can also be significantly influenced by pH (DOE 1993 and 1994). However, pH and alkalinity are not considered to be important variables apart from controlling mobility under the ambient conditions described above, unless the system is perturbed. Such perturbations could occur if mildly acidic ground water came into contact with previously unsaturated sub-pile soil; or, if chemicals were introduced to the system (e.g., fertilizer components) during future land use (e.g., golf course or crop land). Column tests will therefore be conducted to evaluate the mobility of arsenic, uranium, and vanadium under conditions of (1) ambient pH (basic) and alkalinity, (2) mildly acidic fluid composition, and (3) fluids containing fertilizer components.

The effect of oxidation-reduction reactions in the sub-pile environment will not be evaluated, although such reactions may be important in some systems. Instead, the relatively thin sub-pile environment is conservatively assumed to be open to the atmosphere and under oxidizing conditions. Organic-rich deposits were not encountered in the native soil during previous site investigations. If the sub-pile environment were to become anoxic, such as in reconstructed wetlands, uranium and arsenic would likely become immobile due to precipitation of reduced minerals.

5.3.2 Scope

Column tests will be performed using soil collected at 10 of the 15 sub-pile locations and 2 of the 5 off-pile locations shown in Table 5.3.2–1 and Plate 1. The soil samples will be split in the laboratory for the purpose of conducting 2 column tests per sample. One test per sample will be conducted to evaluate contaminant mobility under ambient or baseline conditions. The solution used in these tests will represent irrigation water and precipitation that infiltrates and interacts with the sub-pile soil to attain observed values of pH and alkalinity (Section 5.3.1). A second set of tests will be conducted using five sub-pile samples and one off-pile sample and a solution that represents background ground water. These tests will represent a scenario in which mildly acidic ground water of moderate alkalinity intersects the sub-pile vadose zone during a significant rise in the water table. The third and final set of tests on the remaining 6 samples will include the addition of plant fertilizer to the influent solution to represent the golf course scenario. The fertilizer will be obtained from Intermountain Farmers Association and will be the same formulation that is applied to the golf course (Blue Mountain Meadows) west of the Millsite. The twelve column test samples will be selected from those shown in Table 5.3.2-1 and Plate 1 after the results of the metals analyses have been reviewed. If the analytical results from some sub-pile locations are similar to those from off-pile locations, soil from sub-pile locations may be substituted for soil from the 2 off-pile locations in the experiments.

Table 5.3.2–1. Soil Sampling Locations for Vadose Zone Column Tests

		Millsite Sub-Pil	e Locations			
Grid	Depth [ft] Former I		Grid	Depth [ft]	Former Pile Area	
1845	2-3	Carbonate	3287	2-3	Acid	
2919	2-3	Vanadium	3417	2-3	Vanadium	
2919	4-5	Vanadium	3710	2-3	East	
3022	0-0.5	Vanadium	3947	0-0.5	East	
3051	0-0.5	Vanadium	3947	2-3	East	
3197	0-0.5	Acid	4437	0-0.5	East	
3197	2-3	Acid	4536	0-0.5	East	
3223	0-0.5	Vanadium	4847	2-3	East	
3254	0-0.5	Acid	5262	0-0.5	East	
3254	4-5	Acid	5262	4-5	East	
		Off-Pile Lo	cations			
1486	0-0.5		3964	2-3		
1999	0-0.5	:	4590	0-0.5		
2200	0-0.5					

Note: Five extra bottles, in addition to the metals characterization sample, will be collected for column tests at each location in this table. Extra bottle(s) have same identification and sample number as the sample collected for metals analysis at the respective location and depth. All sample bottles are 500 mL capacity.

Task 2 sample bottles (this table) will not be submitted for chemical analysis by the GJO Laboratory. Instead, Task 2 sample bottles will be temporarily archived.

The sub-pile locations were selected to achieve a somewhat even distribution in areas where remediation is not anticipated to extend to bedrock or beneath the water table and are therefore, not expected to be biased high or low for contaminant concentrations. Additional detail regarding the selection criteria and representation of the subsurface sampling locations is provided in Appendix D, Comment 8. Soil samples for the column tests will be collected concurrent with the metals characterization sampling effort (Task 1), and from the same depth intervals and locations. The off-pile sample locations have been remediated to radiological standards and are in areas where only surficial contamination was present. The off-pile samples may be used as a control group or for measurement of Kd in uncontaminated soil (see Section 5.3.3).

5.3.3 Experimental Design

Stock Solution for Baseline Desorption Tests

Stock solutions for the 12 baseline column tests will be prepared at the Environmental Sciences Laboratory to model the chemistry of surface water upgradient of the Millsite. The solution will be formulated to approximate the major ion chemistry, pH, and alkalinity results of the 11 surface-water samples collected during the RI and subsequently at location SW92-01. The results of the sample collected in October 1995 were selected as the stock solution formula. This sample was selected because analyte concentrations, pH, and alkalinity for that sample are generally within maximum and minimum values detected at that location. Field measurements and common ion data in samples collected from SW92-01 are presented in Appendix E. Field measurements include in-situ pH and titration alkalinity, reported as mg/L of CaCO₃. Surface-

water and ground-water alkalinity at the site is assumed to be entirely attributed to dissolved carbonate species (see Appendix D, Comments 10 and 13 for additional information).

Within the range of pH for the surface-water samples (approximately 7.7 to 8.3), the bicarbonate ion (HCO₃) contributes nearly 100 percent of the total alkalinity. The stock solution is intended to represent uncontaminated water obtained from Loyds Lake for irrigation on the Millsite, and also to represent precipitation that chemically equilibrates with soil and rock during infiltration. Column tests conducted using this stock solution will evaluate contaminant desorption behavior under ambient geochemical conditions in the sub-pile vadose zone. A bromide tracer will be added to the solution and monitored during the tests to estimate dispersivity and fluid velocity.

Site SW92-01 is located on South Creek upgradient of the Millsite and the golf course, and is approximately 0.5 mile downstream of the Loyds Lake dam. Montezuma Creek forms at the confluence of North and South Creeks on the golf course. An advantage of formulating the stock solution in the laboratory, rather than using surface water collected from the creek, is the ability to prepare solutions of constant composition from a fixed formula as needed. This will avoid the possibility of sample degradation from in-situ conditions (e.g., pH and alkalinity) during storage and from potential changes in creek water chemistry at different sampling times. The stability of the stock solution will be confirmed prior to and during the tests.

Apparatus and Test Conditions

Columns will be constructed of 2 or 4 inch diameter by 1 to 2 ft clear acrylic plastic. Flow through the column will be maintained at approximately 0.5 cubic centimeters per minute (cm³/min). At this rate, approximately 10 pore volumes will pass through a 2 inch by 1.5 ft column in 5 days (assume 40 percent porosity). Selection of the residence time per pore volume is discussed further in Appendix D, Comment 11. The duration of each test will be 5-7 days (10-14 pore volumes). The pore volume will be empirically determined during each test. One effluent sample per pore volume will be collected for analysis of arsenic, uranium, and vanadium at the GJO Laboratory. Analytical methods and detection limits for the column test effluent samples will be the same as those specified for water samples in the RI. Real-time monitoring of uranium concentration will be conducted more frequently at the Environmental Sciences Laboratory. Some samples will also be periodically analyzed for major ions. During the column tests, pH, Eh, conductivity, and alkalinity will be monitored at a minimum of every pore volume.

To test for the effects of kinetics on desorption, flow to 4 of the columns with relatively high contaminant concentrations will be shut off for about 2 or 3 days and then restarted. An increase in concentration after the shut down will indicate rate limited desorption. If the effect is significant, the process (shut down and restart) may be repeated.

Baseline Mobility Tests

Twelve baseline mobility tests (10 sub-pile samples and 2 off-pile samples) will be conducted using SW92-01 synthetic water. Test conditions will be those described under the preceding heading.

Rising Water Table Scenario

Six column tests (five sub-pile samples and one off-pile sample) will be conducted using a modified stock solution representing background ground water. The solution will be formulated to approximate the major ion composition, pH, and alkalinity of the alluvial ground-water sample collected on October 3, 1995, from upgradient well 92–05, which is located immediately upgradient of the Millsite. The pH and alkalinity of the October 1995 sample (6.67 and 287 mg/L, respectively) represent approximate median values for those parameters among 11 samples collected between November 1992 and October 1997 (see Appendix E for upgradient ground-water sample results). Within the range of pH for the upgradient ground-water samples (pH 6.5 to 7), the bicarbonate ion contributes 100 percent of the total alkalinity. The Eh of the influent stock solution will be measured during the column tests for comparison to ground-water Eh values, which are typically about 70 to 200 millivolts (relatively oxidizing) in upgradient and Millsite samples.

Golf Course Scenario

Six column tests (five sub-pile samples and one off-pile sample) will be conducted using a modified stock solution. Adding fertilizer similar to that applied on the Monticello golf course will modify the solution. The modified solution will be formulated such that concentrations of major ions common to the fertilizer and upgradient surface water (e.g., potassium) are approximately two times greater in the modified solution. The measurement of alkalinity during these column tests will follow the standard method of measurement for water and wastewater in the presence of phosphates (see Appendix D, Comment 14 for additional information). All other conditions will be identical to the baseline tests.

Optional Contaminant Sorption Tests

Contaminant sorption tests may be performed using the two samples collected from the off-pile locations. At the end of the baseline mobility tests, the stock solution will be switched to one modified by the addition of arsenic, uranium, and vanadium. These tests will proceed until a well-defined breakthrough curve is realized. The influent solution will then be switched back to the original stock solution. The tests will conclude when the desorption profile stabilizes. The results will be used to estimate partition ratios using uncontaminated soil.

A preliminary 6-point, variable mass, batch test using a test fluid spiked with 250 micrograms per liter (μ g/L) uranium indicated linear sorption of uranium (Kd ≈ 8.5 milliliters per gram [mL/g]). Under the test conditions (pH = 7.6, alkalinity ≈ 180 mg/L), there was no evidence of uranium or calcite precipitation, indicating a stable test solution. If the optional sorption tests are conducted, similar testing will be repeated to determine appropriate spike concentrations for arsenic and vanadium. In general, the spike concentrations will be similar to those observed in vadose zone soil water and Millsite ground-water samples documented in the RI.

5.4 Task 3: Characterize the Distribution of COCs in Vadose Zone Soil Water

Sampling lysimeters will be installed to characterize the lateral and vertical distribution of dissolved metal concentrations in vadose zone pore water that will remain beneath the former tailings piles after Millsite remediation. Samples of soil water will be collected for analysis of metals (total concentration), major ions, alkalinity, and pH. Filtration will occur as the sample is drawn into the lysimeter; no additional filtration will occur at the time of sampling. Pore water chemistry will be used in conjunction with the Task 1 soil sample results and column test results (Task 2) to evaluate contaminant mobility. The pore water results may also be used as the initial dissolved contaminant concentrations in the vadose zone source term models or calculations.

5.4.1 Scope

Ceramic porous-cup pressure-vacuum lysimeters will be installed at six locations in the sub-pile areas and two locations in off-pile areas. Two lysimeters will be paired at each location for vertical characterization of metals distribution in soil water. The paired installations will include one unit each in the upper and lower halves of the native soil column. Specific locations will be determined when sufficient area has been verified and the areal and vertical extent of the vadose zone is better defined. In general, thicker areas of the sub-pile soil will be selected for lysimeter installation. A soil sample will be collected from the same interval in which the lysimeter is installed for laboratory analysis of metals. The lysimeters will be sampled on a quarterly basis for one year following installation. The lysimeter specifications included in the following sections were adopted from ASTM D 4696–92, "Standard Guide for Pore-Liquid Sampling from the Vadose Zone." The guidance document provides comprehensive coverage of lysimeter design, installation, and sampling. Other information was obtained from Soil/Moisture Equipment Corporation (SEC), which is a manufacturer and distributor of specialty equipment for vadose zone monitoring.

5.4.2 Lysimeter Design and Installation

Each lysimeter will be approximately 24 inches long, consisting of a porous ceramic cup (approximately 2.5 inches long by 1.9 inches in diameter), PVC body tube, neoprene stopper, and nylon or polyethylene pressure-vacuum and sample extraction lines. The ceramic cup will have a 1-bar air entry valve, 45 percent porosity, 2.5 micrometers average pore size, and saturated hydraulic conductivity of 8.6E-06 centimeters per second (cm/sec) (SEC 1998). The cup and body tube will be joined using inert epoxy cement. The cup will not be acid washed prior to installation.

Lysimeters will be installed using a vehicle mounted auger drill rig or hand augering. The borehole diameter will be between 2 and 4 inches larger than the lysimeter cup and body, therefore, the borehole diameter will be between 4 and 6 inches. Hollow stem or solid flight augers may be used. Lysimeters may be installed either through the hollow stem or open-hole. Rigid casing (PVC) may be used to temporarily sheath the vacuum and sample extraction lines during installation and aid placement.

The borehole will initially be advanced to approximately 0.2 ft below the target depth of the lower lysimeter. Field observation will confirm that the target depth is above the water table. The lower 0.2-ft will be backfilled with 200-mesh silica flour. The lysimeter assembly will then be lowered into the borehole and 200-mesh silica flour slurry will be slowly emplaced using a tremie pipe to 0.5- to 1-ft above the top of the porous cup. Prior to installation, the lysimeter may be filled with distilled water to prevent it from floating in the slurry. Stainless steel or PVC centralizers will be used on the body tube to ensure proper placement. The slurry will consist of approximately 1-lb (0.45 kilograms [kg]) silica flour per 0.16 quart (150 mL) of distilled water. Field personnel will document the actual ratio of solids to water in the slurry and the volume used per installation.

The installation will be held in place with the temporary rigid casing until the slurry stabilizes. At this point, the lysimeter will be tested for proper function according to general test procedures recommended in ASTM D 4696-92. If the unit fails, the cause of failure will be corrected or the unit will be replaced. The temporary casing will then be removed and a 0.5 ft-thick layer of bentonite will be emplaced on top of the silica flour. The bentonite will be slurried using a tremie pipe. The remainder of the borehole will be backfilled with #10-20 silica sand to within 0.2 ft of the upper unit, and the installation process repeated. If water was used to prevent the lysimeter from floating, it will be removed at this time.

The surface completion will consist of a protective PVC casing over the vacuum and sample extraction lines, and a concrete pad. The pad will measure approximately 24 by 24 inches and will be 4 inches thick except in the center, where the casing will be embedded into 1 ft of concrete. The protective casing will extend between 2 and 3 ft above the pad surface. A threaded or removable slip joint will be installed approximately 6 inches below the top of the lines so that they are readily accessible for use during sampling. The top of the casing will be capped.

5.4.3 Sampling and Analysis

Each lysimeter will be purged one day after completion to remove water introduced from the silica slurry. The volume of water purged will be recorded and compared to the volume of water introduced during installation. Purging will continue until the volume of water removed is equal to or greater than the volume used in the silica slurry. Alkalinity, pH, and conductivity will be measured in the field if sufficient volume is recovered. After one month, the lysimeters will again be purged to acclimate the porous cup with formation water. The lysimeters will then be sampled during the quarterly OU III ground-water and surface-water monitoring events. Samples will be submitted to the GJO Laboratory for analysis of metals and major ions. Analytical methods and detection limits for the lysimeter samples will be the same as those specified for water samples in the RI. Alkalinity, pH, and electrical conductivity will be measured in the field if sufficient sample volume is available.

5.5 Task 4: Characterize Backfill Materials

It is anticipated that information regarding the type(s) and thickness of backfill to be placed on the Millsite will become available during the OU I site restoration design process. Other placement specifications such as compaction, density, and moisture content will be obtained at that time. In addition, five to ten samples per backfill material source or type will be collected for analysis of particle size gradation and moisture content. Samples will be collected from various depth intervals in the backfill after emplacement.

5.6 Task 5: Estimate Recharge to Aquifer from Areal Sources.

To predict the effect of the residual vadose zone on ground water quality, the volumetric rate of flow from the vadose zone to the aquifer is required in addition to source concentrations. Previous modeling, in which steady state, uniformly distributed areal recharge was specified, indicated that the vadose zone source was sensitive to the areal recharge rate. The rate used in the models was qualitatively estimated as a percentage of the total annual precipitation in the Monticello area. Additional data will be collected to better estimate the areal recharge rate under transient (seasonal) conditions and possible future land use, such as a golf course.

5.6.1 Scope

Two approaches are being considered to estimate the recharge rate on the Millsite: 1) construct lysimeters and measure drainage, and 2) perform water budget modeling. One approach will be selected following technical discussion with the EPA and UDEQ. Details of the data collection task, e.g., lysimeter specifications, sampling locations, or model selection, will also be discussed. Data collection tasks and data uses for each approach are described below.

Lysimetry

Drainage lysimeters will be constructed either at the existing lysimetry facility near the permanent repository, on the golf course west of the Millsite, or on the Millsite during final site restoration. Several installations would be constructed at either site. The lysimeters will be constructed to facilitate collection and measurement of water that has drained through the profile. Instruments will not be installed to monitor moisture content or matric potential. Weighing the soil columns to determine changes in storage is possible at the lysimetry station but will not be possible at the Millsite or golf course sites. For either lysimetry site, drainage will be measured monthly throughout the year.

If the lysimeter facility is used, analogs of the soil and vegetation profiles on the restored Millsite would be built and the watering regime would be replicated. If the golf course or Millsite location is selected, lysimeters will be installed at several locations to account for variation in topography, vegetation, soil type, and soil thickness. Use of the golf course site would not provide a direct analog of Millsite conditions if soil types are dissimilar. Lysimeters installed on the Millsite could serve a dual purpose if the leachate were collected and analyzed for contaminants of concern.

Water Budget Modeling

Recharge will be estimated using a variably saturated flow model. The model will estimate recharge (or drainage) as the difference between total precipitation, evapotranspiration, runoff, and change in storage. Multiple stress periods will be used to simulate transient, seasonal effects of climate, vegetation, and land use. Climatic, irrigation, vegetation, and topographic data will be used as inputs for model calculation of evapotranspiration and runoff. These data are available

through local sources except plant transpiration parameters, which can be obtained from published sources. The data collection activities specific to this approach are to collect undisturbed samples of vadose zone soil (native and backfill) and perform tests to determine moisture retention characteristics, saturated hydraulic conductivity, bulk density, and porosity of the soils. These parameters are generally required to compute flow and storage functions in most variably saturated flow models.

5.7 Task 6: Install and Monitor Temporary Wells

Soil remediation on and downgradient of the Millsite will alter contaminant distribution and flow in the alluvial aquifer from pre-remediation conditions. At present, ground water monitoring capabilities on the Millsite are limited because most prior wells have been abandoned. More importantly, aquifer materials were completely removed over much of the Millsite during surface remediation, and have yet to be replaced. Ground water discharge occurs at the west end of the excavation, which approximately coincides with the western edge of the former Carbonate Pile. Discharge also occurs along much of the northern margin of the excavation, but not along the south side. The water is channeled along the bedrock surface and flows east where it collects against the edge of the excavation at the east end of the Millsite. Much of the water probably reenters the alluvial aquifer at that location.

As backfilling and grading is completed, a network of temporary wells will be installed in phases to re-characterize ground water on the Millsite. Temporary wells will also be installed downgradient of the Millsite to better define the extent of ground-water contamination and ground-water flow, particularly in areas south of Montezuma Creek. Installation of temporary downgradient wells has proceeded independently of Millsite activities (see DOE 1999d for well installation status). The temporary network will be used to monitor ground-water levels and water quality during the period following Millsite remediation and until final site restoration (see Section 7.0 and the IRA Monitoring Plan for monitoring details). Information obtained from the temporary wells will also be used to select locations for permanent long-term monitoring wells (see Section 5.8).

5.7.1 Scope

Temporary monitoring wells are planned for installation at 32 locations. As shown in Figure 5.7.1–1, temporary wells will be installed along several equally spaced north-south transects on the Millsite. Currently existing monitoring wells are also shown in Figure 5.7.1–1. Three to five wells will be installed along each transect. The western transect will extend across the creek valley between the former U.S. Bureau of Land Management compound and the western edge of the Carbonate Pile, coincident with the western extent of the contaminant plume prior to Millsite remediation. The remaining transects will be located progressively eastward to the eastern boundary of the Millsite. Several locations will coincide with previous OU III sampling wells (e.g., wells 91–50, 82–30B, 82–40A, or 91–14). Temporary wells will also be installed at 5 other locations to monitor ground water entering the western portion of the Millsite from the north. A total of 24 temporary wells are planned for the Millsite. The extent to which exposed bedrock areas are backfilled will determine the actual number and locations of temporary wells on the Millsite.

Downgradient of the Millsite, a total of eight temporary wells will be installed. Three will be located in north-south alignment south of existing well 82–07. One temporary well will be installed approximately 75 to 100 ft north of existing well P92–02, and 2 wells will be located between Montezuma Creek and P92–01. The two remaining temporary downgradient wells will be installed south of the creek in alignment with monitoring well 95–03.

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5.7.2 Temporary Well Installation

At each location, a Geoprobe rig and 2 ft lined core barrel will be used to collect soil samples at a minimum of alternate 2-ft intervals. Sampling will be conducted at each location until bedrock is encountered. Continuous sampling near the bedrock surface will minimize error in measuring the depth to bedrock. All boreholes will be logged in the field for lithology, relative moisture, and penetration rate.

At each location, a small diameter well will be installed. Wells will be constructed of 5-ft sections of 0.5 to 1 inch flush threaded Schedule 40 PVC casing, screen (#10 slot), and pointed bottom cap, and a slip joint top cap. One 5-ft screen section will be set with its base at the bedrock surface at each location. Casing will extend 1 to 2 ft above ground surface. Wells may be installed through the drive rods or open hole. Coarse filter pack sand (#10 - 20 silica) will be used to backfill from total depth to 3 ft below ground surface. A 1-ft layer of fine blotter sand (100 mesh) will then be emplaced. The remainder of the annulus will be filled with 0.25-inch bentonite pellets or bentonite powder which will be hydrated with potable water during placement. A small bentonite cap will be formed at ground surface as an additional measure to prevent leakage of precipitation and runoff.

After installation, each well will be developed by performing 2 or 3 cycles of surging and pumping to remove fine sediment from the screen interval and to ensure hydraulic connection between the formation and screen. Ground-water field parameters will not be monitored during development. The location and elevation (ground surface and top of casing) of each well will be determined by land survey methods.

5.7.3 Abandonment of Temporary Wells

Temporary wells will be monitored until final site restoration activities begin. At that time, the temporary wells will be abandoned by pulling the casing and screen from the borehole and backfilling to ground surface with bentonite pellets. The pellets will be hydrated with potable water during placement.

5.7.4 Water Level Monitoring at Temporary Wells

Water levels in the temporary wells will be measured monthly for 4 months after the network is completed and then bi-monthly for the remainder of the monitoring period prior to site restoration. Data will be used to develop water table contour maps from which ground-water flow directions and hydraulic gradients can be interpreted. The data will also be used to determine when steady state flow is attained after reconstruction of the aquifer and creek is completed.

5.7.5 Ground-Water Sampling at Temporary Wells

Ground-water samples will be collected from the temporary Millsite wells as soon as possible after the Millsite monitoring network is complete. Ground-water samples will then be collected concurrent with OU III ground-water sampling rounds (quarterly) until site restoration begins.

Ground-water samples will be collected from temporary downgradient wells as soon as possible after all downgradient wells are installed. At that time, a sample will also be collected from previously existing monitoring wells 82–07, 82–08, 92–09, P92–02, P92–01, and 95–03. Ground water samples will then be collected concurrently with quarterly monitoring rounds until locations for long-term monitoring wells downgradient of the Millsite are selected.

Ground-Water Sampling Methods and Laboratory Analysis

Ground-water samples will be collected from each temporary well for analysis of dissolved contaminants of concern (COC) metals. The samples will be collected by low flow pumping (approximately 1 liter per minute) or bailing. Prior to sample collection, one bore volume (filter pack plus casing) will be evacuated. Ground-water stability parameters will not be monitored. Alkalinity and pH will be measured in the field. Each sample will be filtered in the field (0.45 micron disposable cartridge filter) and then preserved with nitric acid to pH < 2. If conditions prohibit field filtration (e.g., low sample volume), samples will not be acidified until after filtration in the laboratory. Prior to laboratory filtration, these samples will be preserved by cooling. Field personnel will otherwise follow the Monticello Mill Tailings Site, Operable Unit III, Interim Remedial Action Surface Water and Ground Water Monitoring Plan, Revision 2, (IRA Monitoring Plan) (DOE 1999c) for applicable sampling procedures and requirements.

Samples will be submitted under chain of custody to the GJO Laboratory for analysis of dissolved arsenic, cobalt, copper, lead, manganese, molybdenum, selenium, thorium-230, uranium (non-isotopic), vanadium, and zinc.

5.8 Task 7: Install and Monitor Permanent Wells

The temporary wells installed under Task 6 (Section 5.7) will provide characterization data for the relatively short period following Millsite remediation and until final site restoration. Installing permanent wells on and downgradient of the Millsite will accomplish long-term ground-water monitoring. Permanent wells will be installed on the Millsite after monitoring results from the temporary wells have been reviewed and final grading is at or near completion.

This will allow optimum placement of long-term monitoring wells and prevent damage to the wells during restoration. Permanent wells installed downgradient of the Millsite are intended to complement the existing long-term monitoring network. For example, results from the temporary wells may identify areas not previously characterized that require long-term monitoring. Also, the existing well network is not sufficient to monitor the effects of the PeRT wall during the early period of operation.

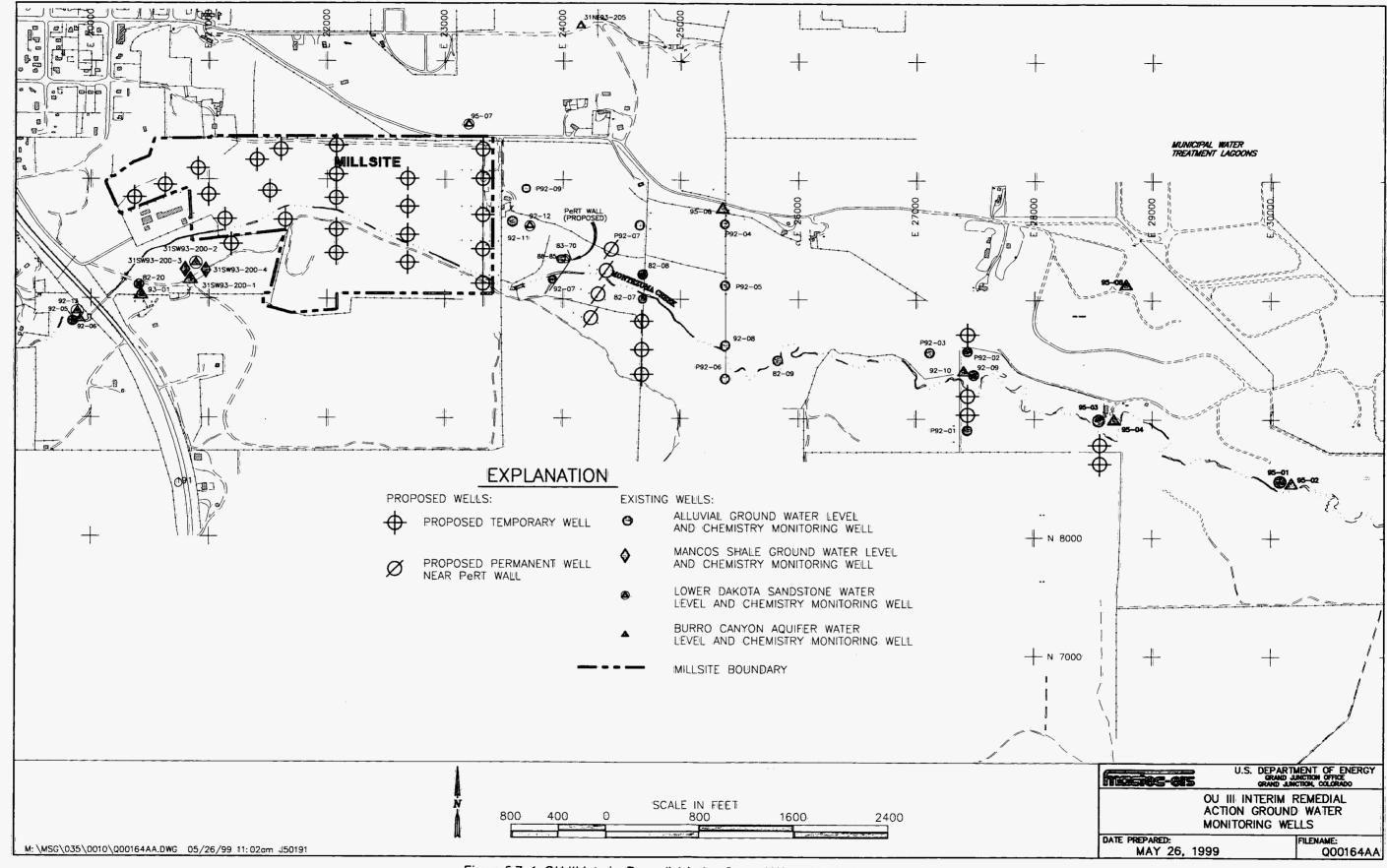


Figure 5.7-1. OU III Interim Remedial Action Ground Water Monitoring Wells

5.8.1 Scope

Three or 4 permanent wells will be installed along each of several transects on the Millsite similar to the temporary network. The permanent well transects will span the width of the contaminant plume and will be placed from the upgradient extent of the plume to the eastern boundary of the Millsite. Wells will also be completed at several locations where previous OU III sampling wells existed prior to abandonment, and at temporary well locations where the highest concentrations of COCs were detected. Permanent wells may be installed before final restoration is completed in areas that will not be significantly re-contoured.

In addition to the Millsite wells, a transect of permanent wells will be installed approximately 200 ft downgradient (east) of the PeRT wall (see Figure 5.7.1-1) so that the effects of that system can be more closely monitored than is possible with the current network. The locations of these wells were selected on the basis of ground-water data obtained during previous PeRT field investigations. Precursor temporary wells will not be installed in this area. Three of the wells in this transect were installed in October 1999 using the Geoprobe rig.

Other permanent downgradient wells will be installed where areas of elevated contamination were identified that are not adequately characterized by the existing monitoring network. For example, if COC concentrations are significantly greater in samples collected south of well 82–07 or 92–09, a permanent well will be installed in those areas.

5.8.2 Permanent Well Installation

A truck-mounted hollow-stem auger rig will be used for borehole drilling, lithologic sampling, and well installation for the remaining permanent monitoring wells. Drilling and continuous sampling will proceed until competent bedrock is reached. Augers will be 7 5/8-inch outer diameter by 4 1/4-inch inner diameter with a retrievable center bit or flexible plug that is locked in place during drilling. A 3-inch outer diameter by 24-inch long split-barrel sampler will be driven ahead of the auger to collect samples. A 140-pound drop hammer with a 30-inch drop will be used to drive the sampler for the length of the sampler or until sampler refusal (>50 blows for each 6 inches of penetration). Once the sampler is full or no further penetration is possible, the sampler is removed from the borehole and opened, allowing the contents to be examined and logged.

Monitoring wells will be constructed using 2-inch inner diameter, flush-jointed, threaded, Schedule 40, polyvinyl chloride (PVC) casing and slotted well screen. An O-ring seal or Teflon tape wrap will be used at each joint. Glues or cements will not be used to connect sections of well casing or screens. All well casing and screens will be either new and factory-sealed, or excess material from previous Monticello programs that is steam-cleaned prior to installation. Well screen lengths will be determined by using the maximum number of 5-ft lengths that do not exceed the saturated thickness of the aquifer. For example, if a borehole penetrates 8 ft of saturated alluvium, 5 ft of screen will be installed. The screen will intercept the maximum amount of permeable, saturated material in the borehole. Transient and seasonally low water levels, if applicable, will also be considered in selecting screen lengths. Screen lengths of wells installed during 1992 and 1995 ranged from 2.5 to 5.0 ft.

The casing assembly and annular backfill materials will be installed through the hollow-stem augers. The filter pack will be installed from total depth to a minimum of 2 ft, and not greater than 3 ft, above the top of the well screen. A 1-ft interval of finer-grained sand will be placed above the filter pack material to prevent intrusion of the bentonite seal into the filter pack. Grain size of the filter pack and screen slot size was determined by sieve analysis for the wells installed during 1992; wells installed during 1995 used equivalent filter-pack materials and screen slot size. Wells installed under this plan will also use equivalent filter-pack materials and screen slot size. Filter-pack material will therefore consist of a uniform, washed, well-rounded, #10 - 20 size silica sand. The upper sand pack will consist of a uniform, washed, well-rounded, #20 - 40 size silica sand. The screen slot size for the alluvial wells will be 0.010 inches (#10 slot). Alluvial wells installed with those materials demonstrated adequate well performance (sample turbidities less than 5 nephelometric turbidity unit [NTU]) in numerous sampling rounds.

A 2- to 3-ft layer of bentonite pellets will be placed on top of the upper sand pack and hydrated. If the bentonite seal is placed above the water table, hydration will be accomplished by slowly pouring approximately 10 gallons of municipal water down from the driller's water tank along the inside surface of the augers. The remainder of the annular space around the casing will be grouted to within 3 ft of the surface with a non-shrinking, bentonitic sealing grout (e.g., Voclay grout or EnviroPlug grout). The grout will be mixed at the manufacturer's recommended mixture ratio. A tremie pipe will be used to install the grout through standing water and in borings deeper than 30 ft. The remaining 3 ft will be filled with cement or concrete. The filter-pack sand, bentonite, and grout will be placed sequentially as the hollow-stem augers are withdrawn from the borehole. The hollow-stem augers will be raised no more than 2-ft above the material level in the annular space during material installation.

A steel cover with locking, hinged, and weatherproof lid will be placed over the riser casing and cemented in place. The clearance between the top of the riser and lid will be about 2 in. The protective cover will be centered in a concrete pad measuring $4 \text{ ft} \times 4 \text{ ft} \times 0.25 \text{ ft}$ thick at ground surface. Three 3 in OD \times 60 in steel guard posts will be placed at 120 degree increments about the well cover. The guard posts will be installed as an integral part of the concrete pad and will be filled with concrete. The guard posts will extend about 30 inches above grade.

All downhole equipment will be pressure washed between boreholes with potable water to remove visible soil. Decontamination water will not be contained. Drill cuttings will be dispersed evenly on the ground in the vicinity of the well.

5.8.3 Monitoring Well Development

All permanent wells will be developed to remove fine-grained material from the well screen, filter pack, and borehole face that could create interferences in water quality analyses, and to improve hydraulic connection between well screen and formation. Well development will begin at least 40 hours after well completion to ensure that sealants and backfill materials have properly cured. Development will be accomplished by cyclical surging with a vented surge block followed by well evacuation with a pump or bailer.

During development, pH, conductivity, temperature, and turbidity will be monitored and the volume of water evacuated recorded. Development will be considered complete when discharge water from the bottom of the well is free of sand and silt; when pH, conductivity, and

temperature have stabilized; and when the turbidity is less than 5 NTU. If all parameters except turbidity have stabilized and the turbidity has stabilized above 5 NTU, well development will be discontinued. Development water will be contained and released to Pond 4, if available, or to another designated decontamination facility.

5.8.4 Long Term Monitoring of Existing and New Permanent Wells

Permanent wells installed under this Plan will be incorporated into the existing OU III ground-water monitoring network for water-level measurement and sample collection as described in the IRA Monitoring Plan (DOE 1999c). The new wells will be sampled quarterly beginning with the first regularly scheduled OU III water sampling event after installation. In addition to the quarterly sampling, the permanent wells installed in the transect closest to the PeRT wall will be sampled immediately after installation to provide baseline information during the very early period of PeRT wall operation.

5.9 Task 8: Collect Samples of Aquifer Matrix for Laboratory Testing

Samples of aquifer substrate will be collected from the saturated zone within the contaminant plume on and downgradient of the Millsite. The samples will be used in column tests to evaluate contaminant desorption rates from the solid matrix to ground water (see Section 5.10). Soil sampling will occur after water levels and contaminant concentrations have approximately stabilized following backfilling on the Millsite.

Samples of imported backfill material will also be collected prior to placement below the water table. These samples will be used in sorption batch tests to evaluate contaminant partitioning between ground water and the imported backfill.

5.9.1 Scope

A sample of aquifer substrate will be collected at 8 locations on the Millsite and 8 locations downgradient of the Millsite. The Millsite soil samples will include native aquifer material and imported backfill in areas remediated to bedrock. Actual sampling locations will be selected after the extent of ground-water contamination has been re-characterized. Each location will be within the post-remediation contaminant plume. The soil samples will be collected adjacent to a monitoring well and coincident with a ground-water sampling event. The soil samples will be analyzed for COCs prior to column testing. Sample results will be used in conjunction with water sample results to calculate contaminant partitioning by the field analytical method described in Section 5.10.

Three samples per source of imported backfill material will be collected at the time of placement in areas where the backfill is anticipated to extend below the water table. The samples will be collected prior to coming in contact with ground water. The samples will be analyzed for COC metals.

5.9.2 Field Sampling Procedures and Laboratory Analysis

Soil Sample Collection Below Water Table

Continuous sampling will be conducted from the water table to bedrock using a Geoprobe rig and lined core barrel. The holes will be located 5 ft east of the adjacent monitoring well. Each sample will be prepared in the field by mixing equal proportions of soil from each sample interval below the water table. Bedrock and material retained by a 0.75-inch sieve will not be included in the sample. Two liters of homogenized sample material will then be transferred into precleaned 500 mL polyethylene sample bottles. If necessary, multiple holes may be completed within 1 to 2 ft of the original location to meet the sample volume requirement.

Each sample will be identified by location (i.e., well location number), sample depth interval, and a unique sample tracking number (sample ticket number). One bottle per sample will be identified to indicate laboratory analysis for metals and pH. The remaining bottles per sample will be designated for archiving. The sample identification information and all other collection information will be recorded in field logs, in the sample ticket book, on sample bottle labels, and sample chain of custody forms. Samples will be delivered under chain of custody to the designated subcontract laboratory for chemical analyses. One 500-mL split of each sample will be submitted to the laboratory for analysis of arsenic, cobalt, copper, lead, manganese, molybdenum, selenium, uranium (non-isotopic), vanadium, and zinc. The pH of each sample will also be analyzed at the laboratory. The remaining bottles per sample will be temporarily archived at the GJO.

Collection of Backfill Prior to Placement

The 3 grab samples of imported backfill soil per each backfill source that are collected during placement will be sieved as per above and transferred into two 500-mL polyethylene bottles. The samples will be delivered under chain of custody to the subcontracted laboratory. One 500-mL split of each sample will be submitted to the laboratory for analysis of arsenic, cobalt, copper, lead, manganese, molybdenum, selenium, uranium (non-isotopic), vanadium, and zinc. The pH of each sample will also be analyzed at the laboratory. The remaining bottle per sample will be temporarily archived at the GJO.

5.10 Task 9: Evaluate Contaminant Mobility in Alluvial Aquifer

Certain contaminant species that enter ground water will partition from the aqueous phase to sorbed phases on aquifer matrix grains. The degree to which partitioning occurs is controlled by the chemistry of the contaminant species, and by system-specific properties of the substrate and fluid chemistry. Many of the OU III COCs are believed to be reactive species and therefore sorbed phases are likely to exist in portions of the aquifer that were or currently are in contact with contaminated ground water. The presence of sorbed contaminants will prolong the period for concentrations to decrease to acceptable levels relative to non-sorbing constituents.

After the primary sources of ground-water contamination are removed from the Millsite, uncontaminated ground water from upgradient of the Millsite will come in contact with sorbed contaminants and desorption will occur. Ground-water concentrations may thus initially increase

at some Millsite locations. A portion of the contaminants mobilized in this way will also then become sorbed to the imported backfill materials placed below the water table. At a given location, the dissolved and sorbed concentrations will progressively decrease if flow of uncontaminated ground water to the system is maintained and no other source of contamination is present.

Column tests will be performed to evaluate contaminant desorption of selected COCs from soil that is within the post-remediation contaminant plume. The water used in the tests will be prepared in the laboratory to approximate the composition of ground water entering the Millsite from upgradient sources. The column tests are intended to represent analogs of contaminant flushing that will occur in the alluvial aquifer following Millsite remediation. The results will provide a qualitative indication of the rates at which COC concentrations will decrease in the alluvial aquifer. In addition, the column tests will be used to qualitatively evaluate the importance of kinetics in controlling desorption.

The column test results will also be used to estimate distribution coefficients by the methods described in Section 5.3. In addition, Kd values for selected metal COCs will be estimated from laboratory batch testing, and by a field analytical method in which Kd is calculated as the ratio of soil to fluid concentration in co-located soil and ground-water samples.

5.10.1 Column Tests Scope

Ten column desorption tests will be conducted using aquifer materials collected within the post-remediation contaminant plume at 5 locations on the Millsite and 5 locations downgradient of the Millsite. Column test samples will be selected to span the range of contaminant concentrations in ground-water and aquifer substrate samples collected and analyzed under Tasks 6 and 8 (Sections 5.7 and 5.9). A synthetic water will be used in the column tests to represent the major ion chemistry, pH, and alkalinity of background ground water that enters the site from sources to the west. Desorption of arsenic, uranium, and vanadium will be evaluated in the column tests.

5.10.2 Column Tests Experimental Design

Stock Solution

The stock solution for the alluvial aquifer desorption tests will be the same as that used in the rising water table scenario for the vadose zone column tests (upgradient ground-water samples collected at well 92–05 on October 3, 1995, see Section 5.3.2 and 5.3.3). A bromide tracer will be added to the test fluid and monitored during the tests to estimate dispersion and fluid velocity in the columns.

Apparatus and Test Conditions

The apparatus used in the aquifer desorption tests will be identical to that used in the vadose zone desorption tests (Section 5.3.3). In general, the remaining experimental conditions (i.e., flow rate, test duration, and parameter sampling and analysis) will also be the same. On the basis of the estimated volume of the uranium plume and the volumetric ground-water flux at the site (Appendix C, Calculation No. Q00073AA and No. Q00077AA), column tests conducted under

these conditions will represent about 40 to 55 years of flushing the uranium plume that existed prior to Millsite remediation (approximately 4 years per pore volume of uranium plume). Several tests will be conducted to evaluate the effects of kinetics in the desorption process, as described in Section 5.3.

5.10.3 Batch Tests Scope

Sorption batch tests will be conducted at the Environmental Sciences Laboratory using three samples of imported backfill that will be placed in areas that were remediated to bedrock. These samples will not have had any contact with ground water at the site. The batch tests will be conducted to determine Kd values for arsenic, uranium, and vanadium. Three to five batch tests per sample will be performed at variable mass and fixed fluid composition. The duration of each batch test will be 24 hours, after which the fluid will be collected and submitted to the subcontracted analytical laboratory for analysis of arsenic, uranium, and vanadium. The Environmental Sciences Laboratory will provide data reduction and calculation of Kd.

5.10.4 Batch Test Experimental Conditions

Stock Solution

The stock solution for the batch tests will be the same as that used in the vadose zone rising water table scenario and the aquifer column tests (i.e., background ground water). The batch test solution will be spiked with arsenic, uranium, and vanadium to result in concentrations that are comparable to those detected in the ground-water sample collected from well 92–11 in January 1999 (0.016, 1.40, and 0.72 mg/L, respectively). Samples collected from well 92–11, which is located 250 ft east of the Millsite, have generally exhibited the highest COC concentrations in downgradient wells throughout the OU III monitoring program.

Concentrations of COCs on the Millsite prior to surface remediation were generally about 2 to 4 times greater than at well 92–11. Arsenic and vanadium concentrations decrease to background levels within approximately 1,400 ft and 2,000 ft east of well 92–11, respectively. Downgradient of well 92–11, uranium concentrations within the plume range from about 1 mg/L at well 92–07 to about 0.250 mg/L at well 92–09. Uranium concentrations then decrease rapidly to about 0.005 mg/L at well 95–03, located 1,200 ft east of 92–09.

Apparatus and Test Conditions

The batch tests will be conducted following procedure CB(BE-3), Determination of Distribution Ratio (Rd), Environmental Sciences Laboratory Procedures Manual (MAC 1999). General conditions of the batch tests include weighing 5 to 25 gm of air dried, disaggregated sample into a 125 ml flask, then adding 100 mL of test fluid, and agitating the mixture for 24 hr. A control sample (no solid sample) is run during the test. The fluid is then separated by centrifugation, filtered and preserved, and analyzed for constituents of concern. The process is repeated by varying the mass of sample to provide a multi-point sorption isotherm.

5.11 Task 10: Select New Locations for Long Term Surface-Water Monitoring

On the Millsite, three surface-water monitoring locations SW99-01, SW99-02, and SW99-03 were added to the network in January 1999 for periodic monitoring. Location SW99-01 is a permanent monitoring location located along Montezuma Creek in the vicinity of the former Bureau of Land Management compound; SW99-02 and SW99-03 are temporary monitoring locations. Additional long-term surface-water monitoring locations on the Millsite will not be selected until the final alignment of Montezuma Creek and other surface-water bodies are established. It is anticipated that one long-term location will then be located on Montezuma Creek near the eastern boundary of the Millsite, and another will be on the creek near the former Carbonate Seep between the former Carbonate and Vanadium Piles.

In April 1999 one sampling location (SW99–04) was added to the OU III long-term surface-water monitoring network. The location is approximately 200 ft downstream of the permanent pond constructed at the eastern extent of soil remediation in Upper Montezuma Creek. The final proposed new surface water site will be downstream of the PeRT wall in the vicinity of the former W–4 location. The new location will be established after the creek in this area has been reconstructed. Sampling at location SW95–01, which is on Vega Creek, will be resumed during the April and October events. Existing and proposed surface-water monitoring locations are shown on Figure 5.11–1.

5.12 Task 11: Aquifer Testing

Aquifer pumping tests will be conducted at 2 locations to determine hydraulic conductivity of the alluvial aquifer. Hydraulic conductivity is a fundamental property that describes the capacity of an aquifer to transmit water. It is used routinely in the calculation of flow rates in numerical and analytical ground-water flow models. One pumping test will be conducted in an area of the Millsite where a significant volume of imported backfill will extend below the water table. The other test will be conducted in native deposits downgradient of the Millsite in the vicinity of the PeRT wall. The tests will be conducted when water levels have stabilized after Millsite remediation and PeRT wall installation.

5.12.1 Pumping Test Methods and Data Analysis

Aquifer tests will be conducted in general accordance with ASTM procedures D4043–91, "Standard Guide for the Selection of Aquifer-Test Method in Determining of Hydraulic Properties by Well Techniques", and D4050–91, "Standard Test Method (Field Procedure) for Withdrawal and Injection Well Tests for Determining Hydraulic Properties of Aquifer Systems." Existing permanent wells will be used as the pumping wells. Additional temporary piezometers will be installed as observation wells. Preliminary calculations will be made to determine the appropriate number and spacing of observation wells using hypothetical pumping rates, duration, and hydraulic conductivity.

The pumping test will be conducted at the maximum sustainable rate of withdrawal. This will be determined by short-term step-tests conducted prior to the pumping tests. The initial extraction

rate in the step-tests will be about 1 gallon per minute (gpm). Pumping will continue at that rate until drawdown in the well stabilizes. This process will be repeated at different rates to determine the maximum sustainable yield for the well. Water levels will be allowed to fully recover prior to starting the actual pumping tests.

The aquifer tests will be performed by pumping the well at a constant discharge for at least 48 hours. Literature sources report that the minimum pumping time required to attain a delayed-yield response in an unconfined aquifer is approximately 30 hours. Flow will be measured by using an instantaneous in-line flow meter such as a Great Plains Industrial flow meter or equivalent. Flow rates will be recorded on a data form or in a logbook. Recovery of ground-water levels (residual drawdown) will be measured until 95 percent of the maximum drawdown has dissipated.

Water levels will be measured with pressure transducers from In-situ, Inc. (or equivalent). Transducer sensitivity and installation depth will follow manufacturer recommendations for expected drawdown and total head above the transducer during the tests. Transducer setup parameters, installation depth, model, and serial number will be recorded in a field logbook before the start of data collection. Water-level data will be recorded using the In-situ, Inc. Hermit model data logger, or the In-situ, Inc. SENTINEL model, or the Geoguard Tuber Model. The data logger will be programmed to a logarithmic sampling schedule and will display and record data in the "depth to water" mode relative to the top of the casing. To verify the accuracy of the transducers during the monitoring period, the "depth to water" displayed on the logger will be compared with manual readings taken with a water-level sounder. User manuals from In-situ, Inc. or Geoguard will be followed for logger setup, calibration, and programming.

Baseline water-level data will be collected during the tests from selected monitoring wells located beyond the radius of influence. Baseline water levels will be collected at eight-hour intervals during the withdrawal and recovery periods. If possible, baseline data will also be collected at 12 hour intervals for several days prior to testing, including the pumping and observation wells. The baseline water-level data will be used to identify regional trends that might influence data interpretation.

After completion of data collection, the information will be downloaded from the field logger to a laptop computer. The results will then be processed using commercially available software for aquifer test analysis. Transmissivity, hydraulic conductivity, and storage properties will be determined by fitting the observed drawdown and recovery curves to various analytical solutions of unconfined and unsteady flow.

Document Number Q00149AD

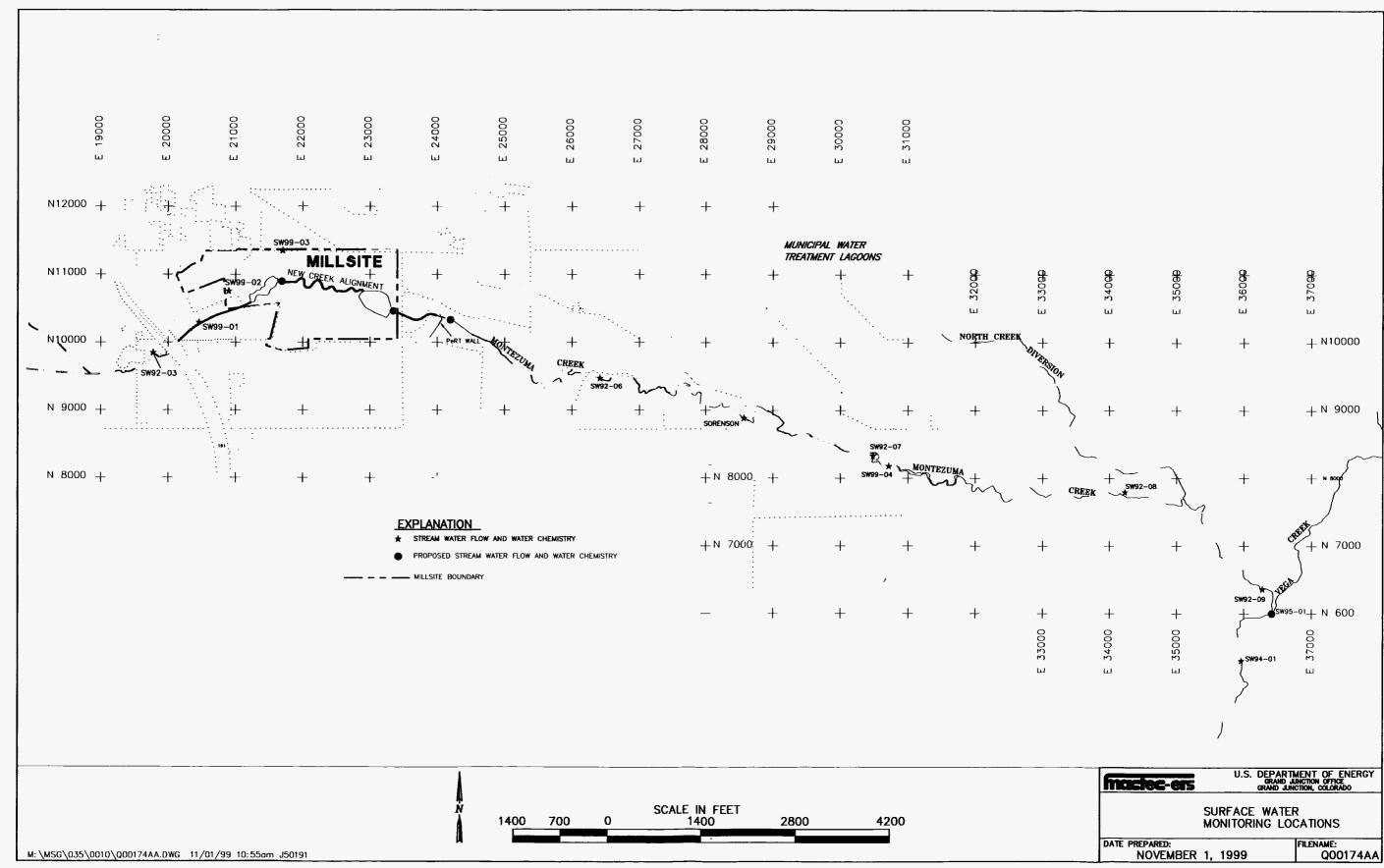


Figure 5.11–1. Surface Water Monitoring Locations

6.0 Permeable Reactive Treatment Wall Treatability Study

A pilot scale treatability study for the evaluation of a PeRT wall for the in-situ treatment of ground water is being conducted at the MMTS. The treatability study is being conducted on a large enough scale that it is anticipated to have an impact on the ground water quality of the alluvial aquifer. The PeRT wall treatability study involves deployment of a system consisting of a reactive media gate and impermeable walls to treat contaminated ground water. Field characterization, field material treatability studies, design specifications, and installation have largely been completed through a separate DOE project (the Accelerated Site Technology Development Program from DOE's Office of Science and Technology) although activities have been closely coordinated with the OU III IRA. Additional information regarding the PeRT wall treatability study is included in the final documents (listed below).

- Deployment Plan for the Permeable Reactive Treatment Wall for Radionuclides and Metals (DOE 1997b)
- Design Specifications for the Monticello Millsite PeRT Wall Demonstration Project (DOE 1998i)
- Permeable Reactive Treatment (PeRT) Wall, Characterization Report (DOE 1998j)
- Permeable Reactive Treatment (PeRT) Wall, Results of Field Treatability Studies for the Monticello, Utah, PeRT Wall (DOE 1998k)
- "Results of Preliminary Groundwater Flow Models for Baseline and Various Permeable Reactive Treatment (PeRT) Wall Configurations at Monticello, Utah" (Cromwell 1998).

Information obtained during the PeRT wall treatability study will be used develop and evaluate use of a PeRT wall as a treatment technology in the revised OU III FS. It is anticipated that decisions regarding continued operation or shut down and decommissioning will be made concurrent with the final OU III remedial action decision. Installation of the PeRT wall was completed in June 1999 resulting in a fully operational wall.

6.1 Task 1: Monitor Treatment Performance of PeRT Wall

The primary objective of the PeRT wall treatability study is to evaluate the effectiveness of the PeRT wall system in reducing the concentrations of arsenic, molybdenum, selenium, vanadium, and uranium to preliminary remediation goals. Other objectives of the study are to

- 1) Determine the concentrations of iron and manganese in the ground water exiting the PeRT wall to determine how much is leaching from the zero-valent iron (ZVI) reactive media.
- Determine the capacity of the ZVI to create reducing conditions within the PeRT wall by documenting geochemical characteristics of the ground water including pH, redox potential, dissolved oxidation, and iron.

- 3) Determine the tendency for the PeRT wall to clog by minerals precipitating within the ZVI media. The amount of the wall clogging will ultimately impact the longevity of the PeRT wall system.
- 4) Determine ground water residence time and flow patterns within the PeRT wall. Changes in the subsurface flow conditions (i.e. changes in the hydraulic head distribution) may indicate changes in the PeRT wall hydraulic conductivity.

The performance of the PeRT wall system as a treatment technology will be evaluated by ground water monitoring. Water quality data will provide information on the reduction of contaminant concentrations, leaching of iron and manganese, and the geochemistry of ground water within the reactive media. Water level measurements will be used to determine if gradients across the site are stable or are increasing, indicating that clogging may be occurring.

A tracer test will be performed to measure ground water residence time. Tracer test data will also be used to determine if preferential flow pathways have formed that could change the performance of the PeRT wall.

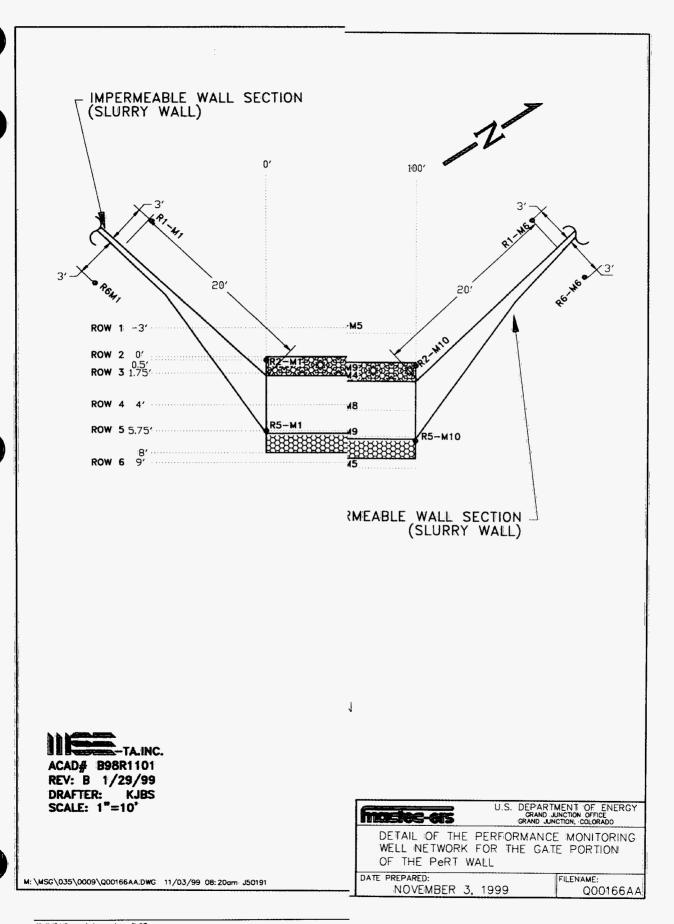
6.1.1 Ground-Water Monitoring Scope

PeRT wall performance monitoring will occur at 55 wells that will be installed within and immediately adjacent to the reactive media or slurry walls (Figure 6.1.1–1). Thirty-six of those wells will be completed in the reactive media gate. Five wells will be located 3 ft from the gate along the upgradient and downgradient sides. Five more wells will be placed downgradient of the gate, starting about 25 ft from near the center of the gate, and then on 20 ft centers along a line that is slightly oblique to the direction of ground water flow. The remaining wells will be 3 ft from the upgradient and downgradient sides of the slurry walls about 20 feet from the gate.

Wells out side of the reactive media will be installed as soon as possible after the PeRT wall is completed. Wells within the reactive media gate will be installed approximately two to four weeks after the gate portion is completed. Well installation and construction specifications are provided in Section 5.7.2, except that the PeRT wall performance wells will include a concrete pad at ground surface (1 ft \times 1 ft \times 0.5 ft thick) into which a flush-mount metal protective casing with bolt-down cover will be installed. In addition, the wells at the tracer injection locations will be constructed of larger diameter (1 or 1.25 inch) casing and screen.

The water level in each PeRT wall performance well will be measured immediately after completion (July or August 1999) and then monthly through November 1999. During this period, unsteady flow is anticipated as the aquifer responds to the PeRT system, cessation of dewatering on the Millsite, and realignment of Montezuma Creek. Water levels will then be measured quarterly beginning in January 2000. A contour map of the water table will be developed after each measurement event.

Ground water sampling will occur monthly in September, October, and November 1999 and then quarterly beginning in January 2000 in conjunction with the surface water and ground water monitoring program which includes additional monitoring wells located upgradient and downgradient from the PeRT wall. Ground water samples will be collected from all 55 PeRT wall performance monitoring wells during each event for arsenic, molybdenum, selenium,



vanadium, and uranium. Samples will be collected from four transects of wells within the reactive media for common ion analyses; common ion samples will be collected in September, October, and November 1999 and then quarterly beginning in January 2000. Samples will be collected from three transects of wells within the reactive media for iron and manganese analyses and from the five downgradient wells beginning 25 ft from the gate; iron and manganese samples will be collected in September, October, and November, 1999 and then quarterly beginning in January 2000.

The frequency and locations of long-term monitoring will be determined after the results obtained over the first two years of PeRT wall operation are reviewed. Additional sampling details regarding the PeRT wall performance monitoring may be found in the OU III, IRA Surface Water and Ground Water Monitoring Plan (DOE 1999c).

6.1.2 Reactive Media Tracer Test Scope

The scope and methodology of the tracer test through the reactive media will be determined after the success and results of the slurry wall tracer test have been evaluated.

6.2 Task 2: Monitor Performance of PeRT Slurry Walls

The effectiveness of the PeRT slurry walls in capturing and diverting ground water to the gate will be evaluated by monitoring ground water levels and conducting a bromide tracer test. The water level data will be used to develop contour maps of the water table from which flow directions and travel paths in the PeRT area can be inferred. The tracer test will be conducted to determine if leakage is occurring through or beneath the slurry walls.

6.2.1 Scope

Twenty-eight piezometers will be installed for water level and tracer test monitoring as soon as possible after the PeRT wall is completed. These will be in addition to the wells installed to monitor treatment effectiveness (Section 6.1). Figure 6.2.1-1 shows the locations of the proposed wells that will be used to monitor the performance of the PeRT system, except those located in the reactive media. Downgradient of the slurry walls, preferential flow paths, such as gravel conduits or bedrock troughs, will be targeted for piezometers placement. Such areas may be identified during wall construction, or from borehole data collected during piezometer installation. The actual locations of the downgradient piezometers may therefore differ from those shown in the figure. Along the slurry walls, the piezometers will be 3 to 5 ft from the edge of the wall. If slurry from trench loss is evident at those locations, the piezometers will be moved beyond the effected zone.

Piezometers will be installed according to the installation and construction specifications provided in Section 5.7.2.

The water level in each PeRT piezometers will be measured immediately after completion (July or August 1999) and then monthly through November 1999. During this period, unsteady flow is anticipated as the aquifer responds to the PeRT system, cessation of dewatering on the Millsite,

and realignment of Montezuma Creek. Water levels will then be measured quarterly beginning in January 2000. A contour map of the water table will be developed after each measurement event.

6.2.2 Tracer Test

After the PeRT system is installed and ground water flow stabilizes, a bromide tracer test will be conducted to further evaluate slurry wall performance. A pulse of tracer will be injected into the aquifer at wells located on the upgradient side of the north and south slurry walls. Tracer movement will then monitored on both sides of the slurry walls until sufficient time has elapsed for tracer to arrive at the detection wells.

Stock Solution Formula and Preparation

The tracer solution will be prepared in the field using potable water and dry sodium bromide (NaBr). The solution will be prepared in 250 gallon polyethylene tanks. Tracer will be injected at one location along the north wall and 3 locations along the south wall. Stock solution for the north wall test will be prepared and injected prior to beginning the south wall test. Three tanks of solution will be prepared and simultaneously injected at 3 locations along the south wall (see Figure 6.2.1–1).

Two-hundred gallons of tracer solution will be prepared at each location. The concentration of bromide in the solution will be 60 grams per liter (g/L). About 130 pounds of NaBr (equivalent to 45 kg Br) will be required to prepare 200 gallons of solution to achieve that concentration. Mixing will be accomplished using a submersible pump or trash pump to recirculate the fluid as NaBr is added to the water. The concentration of the solution will be measured with a bromide selective electrode to verify the final concentration. A sample of the final solution will also be collected for laboratory confirmation. Prior to conducting the test, ground water samples from the annual monitoring network will be analyzed for bromide to determine ambient bromide concentrations and confirm that the tracer and stock formula is appropriate.

In order to arrive at a starting concentration and volume of tracer, calculations were performed using an analytical solution of the advection-dispersion equation to estimate bromide concentrations in receptor wells (Equation 1). The first step in the calculation involves estimating the ground water flow velocity by Equation 2, which is a variation on Darcy's Law. Approximate values for hydraulic conductivity in the PeRT area are believed to be about 5×10^{-3} to 1×10^{-2} cm/sec, with 30 percent porosity, and a gradient of 0.02. The average linear velocity calculated from these values is therefore 1 to 2 ft/day.

$$C_{\text{max}} = V_o C_o [8(\pi t)^{3/2} (D_x D_y D_z)^{1/2}]^{-1}$$
 [Equation 1]

where:

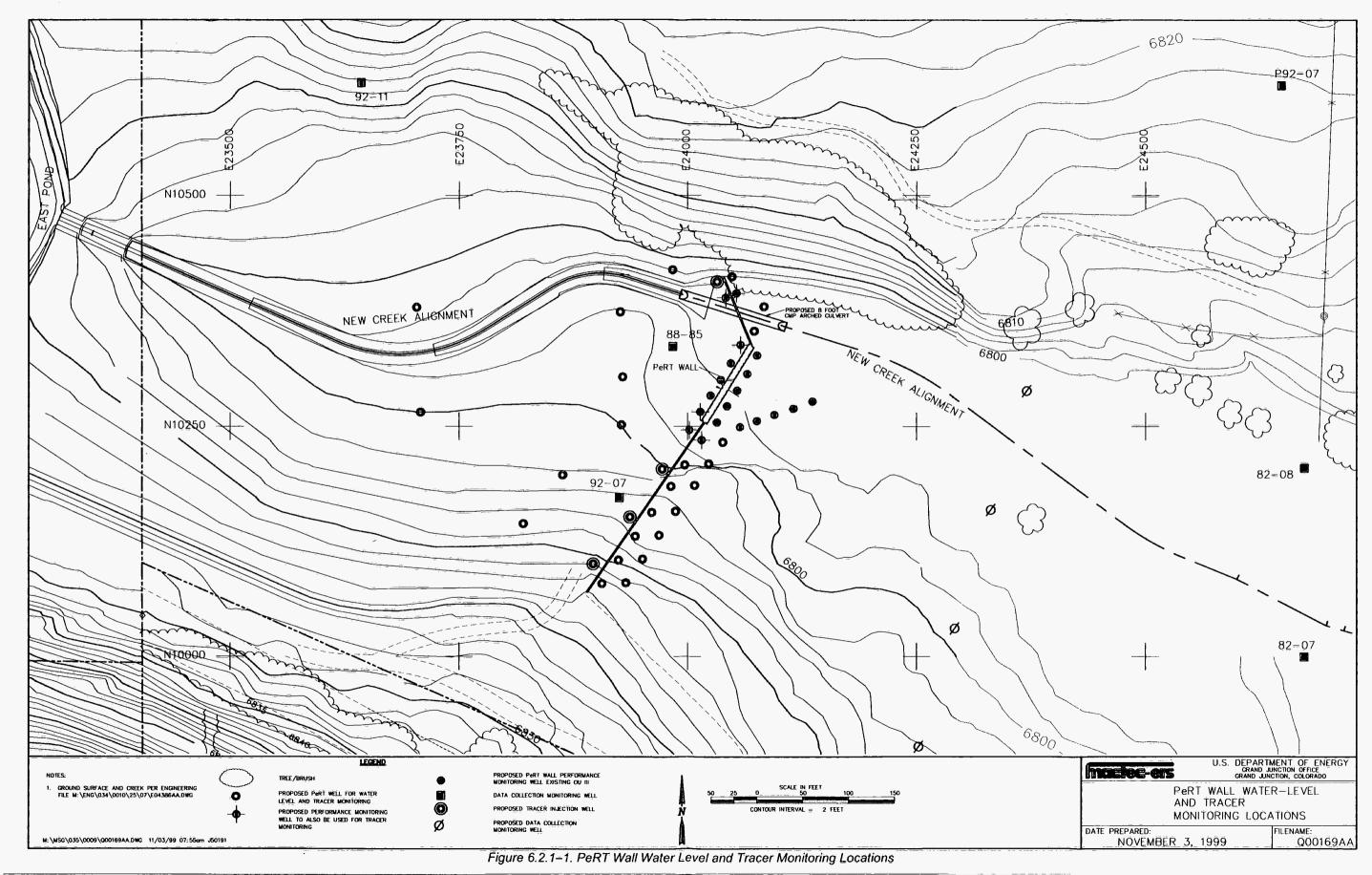
 C_{max} = maximum bromide concentration at time t $[M/L^3]$

 V_0C_0 = mass of bromide injected [M]

t = time[T]

 D_x , D_y , D_z = coefficients of hydrodynamic dispersion [L²/T]

= dispersivity in x, y, and z directions [L] × velocity [L/T]



 $v_{avg} = Ki/n$ [Equation 2]

where:

v_{avg} = average linear flow velocity [L/T] K = hydraulic conductivity [L/T]

i = hydraulic gradient [L/L]

 $N = porosity [L^3/L^3]$

As shown in Figure 6.2.1–1, each downgradient detection well will be within 100 ft of an injection well in the general direction of ground water flow. Assuming that the ground water velocity is 1 ft/d, the maximum concentration of bromide in the center of the plume will hypothetically arrive at a downgradient well 100 ft from the source in 100 days. Using that travel time and velocity, and values for longitudinal, transverse and vertical dispersivity of 10 ft, 1 ft, and 1ft, respectively, Equation 2 predicts a maximum concentration of 11.4 mg/L. Longitudinal dispersivity was assumed to be one-tenth of the travel distance, transverse and vertical dispersivity were assumed to be one-tenth of the longitudinal dispersivity. The predicted concentration can be readily detected by conventional laboratory methods, as described later. The starting concentration may be modified using the same approach if hydraulic gradients, flow directions, and travel distances are observed to differ significantly from those above after the PeRT wall is installed.

Tracer Injection

Tracer solution will be injected at about 1 to 2 gpm by pumping with a submersible or peristaltic pump, or by siphoning from the stock tank. At that rate, injection should be completed in approximately 2 or 3 hours. Greater rates may be used as the pumps, well, and formation permit. Pumping tests using 2 inch wells in the alluvium on the Millsite were able to sustain withdrawal rates of 11 to 13 gpm. Using 1 or 1.25 inch diameter injection wells will probably not be a limiting factor at the anticipated injection rates.

The solution will be delivered through polyetheylene tubing that is lowered to the base of the well. Fluid levels will be monitored periodically and maintained below the top of the slurry walls at all times. Injection at the 3 locations along the south wall will occur simultaneously.

Tracer Monitoring Locations, Frequency, and Method

Tracer movement will be monitored at 26 locations, corresponding to the 6 wells adjacent to the upgradient sides of the walls, the 2 upgradient corners of the gate, 4 wells east of the north wall, and 14 wells east of the south wall. Monitoring will be conducted until tracer is detected at the upgradient corners of the gate. This will allow sufficient time for tracer that had leaked through a compromised portion of the wall or beneath the wall to reach a downgradient detection well. The monitoring period will be extended if hydraulic gradients, flow directions, or travel distances indicate greater arrival times.

Samples will be collected at each location on a weekly basis using a bailer or peristaltic pump. Unfiltered samples will be collected in one 125 mL polyethylene bottle and cooled to 4 degrees Centigrade until laboratory analysis.

Bromide Analysis

Samples will be submitted to the GJO Laboratory for bromide analysis using ion chromatography. The method can achieve detection limits of about 8 μ g/L. Potential interfering ions are nitrite and nitrate, which elute near the bromide peak. Interference is generally not significant when nitrate concentrations are below about 100 mg/L. Recent samples from wells in the PeRT area (88–85, 92–07, and 92–11) contained up to 5 mg/L of nitrite plus nitrate as nitrogen. Previous analyses indicate that nitrite does not contribute significantly to the normalized results. Converting 5 mg/L nitrate as nitrogen results in a nitrate concentration of about 20 mg/L. Interference form nitrate and nitrite will therefore be minimal in the bromide analyses.

7.0 Ground- and Surface-Water Monitoring

Ground-water and surface-water monitoring during the period from October 1997 through October 1998 consisted of semi annual sampling that was performed in accordance with the Monticello Mill Tailings Site, Operable Unit III, Annual Monitoring Program (DOE 1997d). After discussion among DOE, EPA, and UDEQ during fall 1998, the program was modified to increase the frequency of sampling to quarterly (beginning in January 1999) and to increase the number of locations sampled east of the Millsite. The revised program was presented in draft form as Monticello Mill Tailings Site, Operable Unit III, Interim Remedial Action, Annual Monitoring Program (DOE March 1999e) and was expanded in May 1999 to include the monitoring requirements for the PeRT wall treatability study. The May 1999 version of the Plan is called the Monticello Mill Tailing Site, Operable Unit III, Interim Remedial Action, Surface Water and Ground Water Monitoring Plan (DOE 1999c). Minor comments were received from the regulatory agencies in August 1999 on the Surface Water and Ground Water Monitoring Plan and do not result in any significant technical changes. The Plan will be reissued in December 1999 as a final document.

All field data will be verified and all analytical data will be verified and validated. Analytical data tables, ground water elevation maps, contaminant distribution plots, time/concentration plots, and well hydrographs will be updated and summarized in a Surface Water and Ground Water Data Summary Report that will be prepared yearly. The data summary report will be submitted to the regulatory agencies in December of each year and will contain the data from the previous fiscal year. It is anticipated that the monitoring plan may require periodic updates to incorporate sample collection from new surface-water locations or newly installed monitoring wells; minor changes to the plan will be handled by issuing program directives.

Surface-water and ground-water samples will be collected during the October (fall), January (winter), April (spring), and July (summer) time frames. Surface water and ground water sampling locations are presented in Figures 7–1 and 7–2. PeRT wall performance monitoring locations are presented in Figures 6.1.1–1 and 6.2.1–1. Sampling months may vary slightly in an attempt to match spring high-flow and fall low-flow conditions or because of winter weather conditions. Ground-water level and stream-flow measurements are obtained on a quarterly basis in conjunction with the sampling events.

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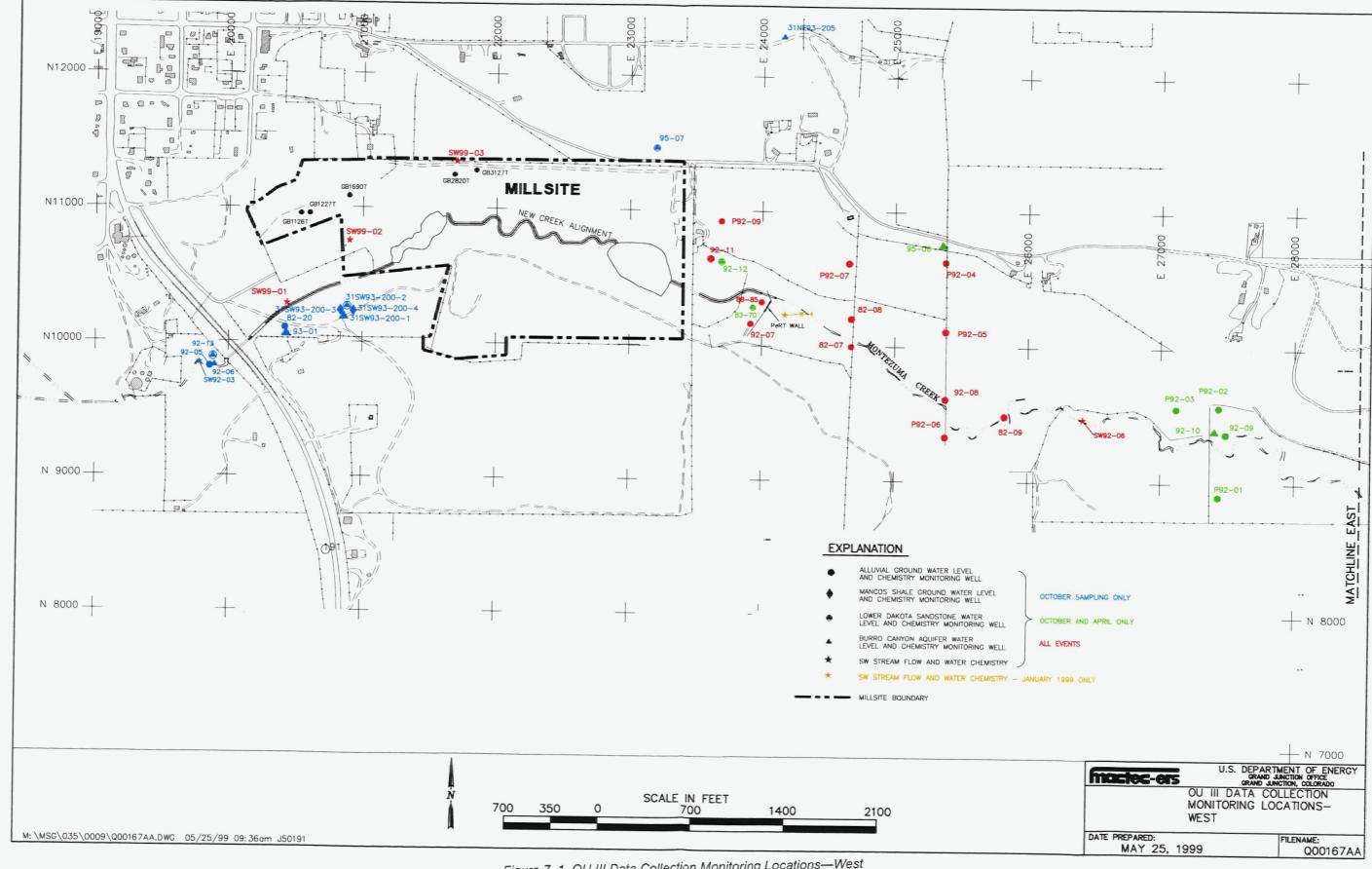


Figure 7–1. OU III Data Collection Monitoring Locations—West

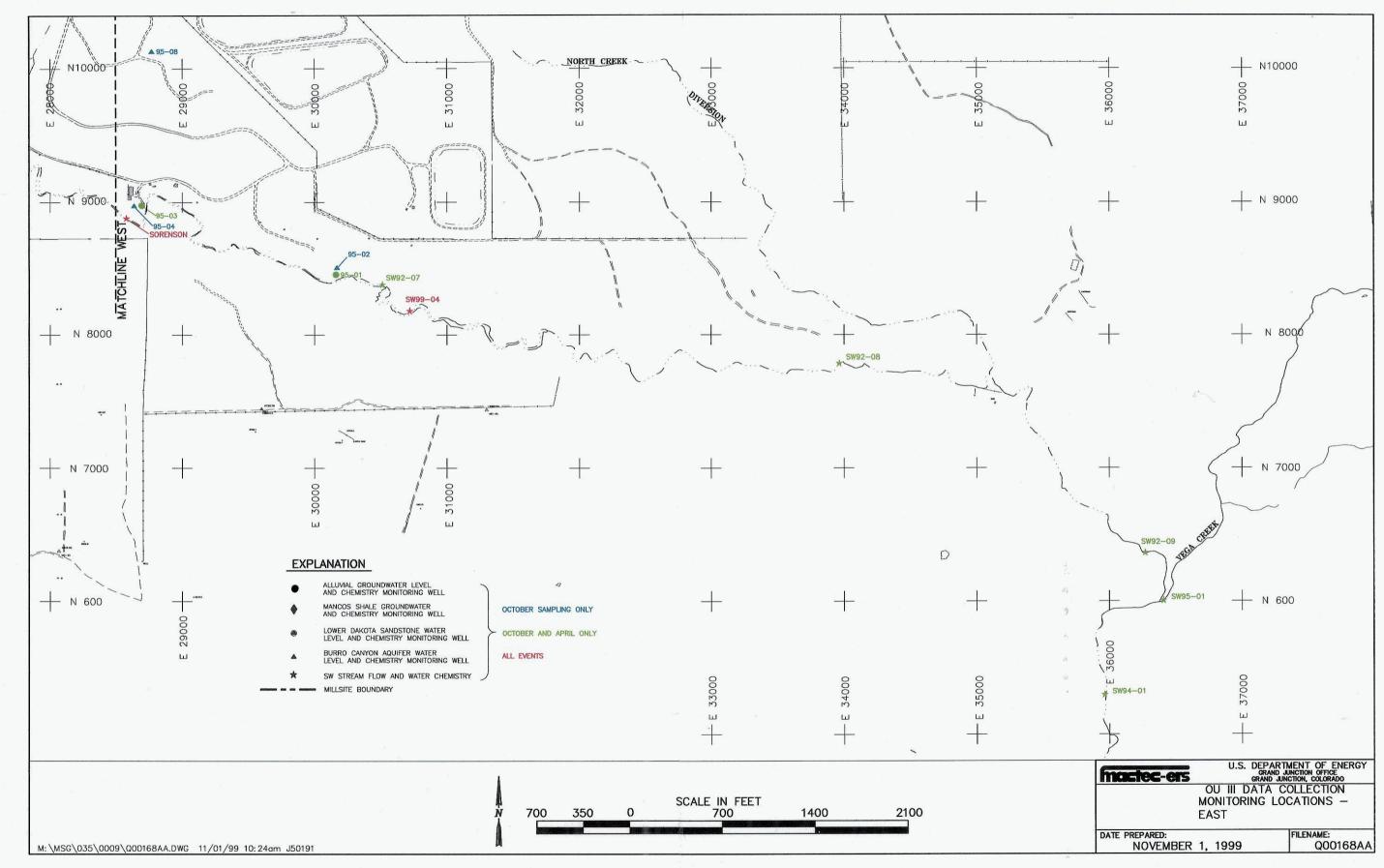


Figure 7–2. OU III Data Collection Monitoring Locations—East

8.0 Remedial Investigation

An addendum will be prepared to the Remedial Investigation report that was finalized in September 1998. The purpose of the RI addendum will be to provide a document that summarizes the site characterization activities that occurred during the IRA and to update the ground water flow and transport modeling and baseline risk evaluation that was presented in the 1998 RI with post Millsite remediation site information.

8.1 Site Characterization

The site characterization that will be described in the addendum to the RI will be those activities that were performed according to the scope presented in Section 5.0 Data Collection, Section 6.0 PeRT Wall Treatability Study, and in Section 7.0 Surface Water and Ground Water Monitoring of the Plan. The primary purpose of these activities is to (1) determine how the Millsite has changed as a result of remediation, (2) observe the effects that remediation has had on surface water and ground water both on and downgradient of the Millsite, and (3) provide input that is necessary for ground water modeling. The Site Characterization section of the RI addendum will be followed by a Nature and Extent of Contamination section that will contain contaminant plume maps, figures depicting surface water contaminant concentrations and data tables. Data collected through January 2003 will be presented in the RI addendum. Data collected after January 2003 will be reviewed and evaluated to determine if it is consistent with the analysis presented in the RI addendum.

8.2 Ground Water Flow and Contaminant Transport Modeling

The ground water flow and contaminant transport models presented in the RI (DOE 1998c) will be revised and updated to reflect changes to the ground water system and contaminant distribution at the site as a result of surface remediation. Information will also be collected during the IRA that was not available when the RI models were developed. Sections 5.0 and 6.0 identify the data needs and data collection tasks for updating and refining the models. This section outlines the modeling approach for the RI Addendum, and describes how the new information will be applied. The conceptual models of flow and contaminant transport at the site will remain essentially the same, and are briefly reviewed. The existing models will be used only as templates for building the new models.

Flow modeling will begin during Fall 2000. Start up activities will include setting the model domain, grid, bottom surface, boundaries, and performing water budget calculations. Data that becomes available during site characterization and reconstruction will continually be developed and incorporated into the model. Preliminary simulations will be run during this period to evaluate model performance. All flow-model data collection and development should be completed in Winter 2002. The hydraulic heads measured in October 2002 or January 2003 will be the final calibration targets. Flow modeling should be completed in about January 2003.

Transport modeling will proceed on a similar schedule, with the completion of data collection and development anticipated in Fall or Winter 2002. Transport modeling activities that will occur prior to then will include determining the areal recharge source (vadose zone source), setting

concentration boundaries, and estimating aquifer dispersivity. The last data to be collected and evaluated will likely be recharge measurements and lysimeter sample results, however, much of the modeling set up can and will occur prior to the final analyses of these data. Ground water sample results from October 2002 will be used to define the staring concentrations in the transport models. The transport models will be finalized and run from about January to March 2003.

The main objective of the RI Addendum modeling will be to estimate future concentrations of contaminants in alluvial ground water, from which the risk to human health can be evaluated. Secondly, the models will represent the baseline condition from which remedial alternatives can be evaluated in the revised FS.

8.2.1 Flow Modeling

Steady-state ground water flow will be numerically simulated using the MODFLOW computer code (McDonald and Harbaugh 1988). MODFLOW is a 3-dimensional, finite difference, block centered, saturated porous media flow model. A windows-based visual pre- and post-processing environment, such as Visual MODFLOW®, will be used to develop, execute, and analyze the site model. MODFLOW will be used deterministically. A parallel model will be developed using stochastic methods.

8.2.1.1 Ground Water Setting and Conceptual Model

The upper aquifer at the MMTS is unconfined and occupies a narrow alluvium-filled bedrock valley. Ground water flow is from west to east. The alluvium consists mainly of sand, gravel and cobbles, with some fines. A small perennial creek (Montezuma Creek) flows along the axis of the valley. The valley is bounded to the north and south by steep bedrock hill slopes. The alluvial materials pinch out against the bedrock and/or colluvial deposits that mantle the bedrock hill slopes. The colluvium consists of a silt and clay matrix that may support gravel and cobbles in some areas. Also common are layers of red loess (silt and fine sand), particularly along the south side, and intervals of bedded shale clasts in a fine matrix (sheetwash deposits). The slope cover is generally not part of the saturated system.

Where the aquifer is contaminated, the upper bedrock is low permeability, variably saturated, mudstones and sandstones of the Dakota Formation. These layers restrict downward movement of ground water to the underlying Burro Canyon sandstone aquifer. The alluvial aquifer extends about 4 or 5 miles east and southeast of the site. Sheer canyon walls about 2 miles east of Millsite bound the alluvium. In this area, the Dakota Formation has been removed by erosion and the upper bedrock in the valley is Burro Canyon sandstone. In the absence of the Dakota Formation ground water from the Burro Canyon aquifer is discharged to the alluvial aquifer. Alluvial deposits pinch out entirely about 1 or 2 miles further down the canyon, where the creek runs over bedrock, and all alluvial ground water is probably discharged.

The Monticello reservoir (Loyd's Lake) is located about 1-mile west of the Millsite. Intentional release and leakage from the reservoir maintains perennial flow in South Creek, which is an upgradient tributary of Montezuma Creek. Influent conditions on South Creek and leakage from the reservoir are believed to support base flow in the alluvial aquifer west of the site. Streams that originate several miles west in the Abajo Mountains supply the reservoir. The alluvial

aquifer is also recharged from suspected cultural sources along the north margin of the valley, where numerous wetland, seeps, and springs have been observed. Recharge from the southern margin is relatively minor and seasonal. It is thought to be limited to drainage ravines that enter the valley. Cropland south of the Millsite is not irrigated and other cultural sources are lacking. Other sources of recharge include precipitation and irrigation returns (cropland east of Millsite is irrigated).

Site conditions will be represented in the numerical flow model by the following specifications:

- 1) Single layer model (no vertical discretezation of hydraulic properties in alluvial deposits).
- 2) Unconfined aquifer (upper surface defined by water table).
- 3) The lower surface of the aquifer is defined by low permeable upper bedrock and will be a no flow condition.
- 4) The lateral (north and south) margins of the aquifer are defined by low permeable bedrock hill slopes and will be no flow boundaries. However, flux boundaries will be assigned in areas where field observations indicate local recharge sources.
- 5) Surficial recharge will be specified. Evapotranspiration will not be simulated. The U.S. EPA Hydrologic Evaluation of Landfill Performance model (HELP) may be used to estimate surficial recharge. Golf course watering will be addressed either in a separate recharge scenario or by sensitivity analysis.
- 6) Montezuma Creek will be represented as an internal hydrologic boundary. The creek bed consists of granular deposits (sand, gravel, and cobbles) and a perfect hydraulic connection to the aquifer will be assumed unless leakage is restricted by engineered controls in some reaches.
- 7) A specified flux or constant head boundary will be assigned at the west end of the model. Constant leakage through the dam at the Monticello reservoir and influent conditions on South Creek west of site are the sources of underflow to the site from the west.
- 8) A boundary will not be specified at the downgradient (east) end of the model.
- 9) Engineered wetlands on the Millsite will not be represented as internal boundaries. They will instead be viewed as surface expressions of the water table.
- 8.2.1.2 Model Conditions That Will Change

Domain

The western end of the active domain will not change. It will remain at the location of well 92-05, approximately 200 feet west of the Millsite. However, the domain will be shortened from the east by about 1.5 miles. The new downgradient end will be at surface water monitoring location SW99-04. This will improve model stability and will not compromise value. There are no monitoring wells in the area removed from the domain or any hydrologic or contaminant features that would alter model representation. Ground water contamination currently extends to about

0.5 mile upgradient of SW99-04, and the RI transport models predicted that contamination would come no closer than that during a 100-yr simulation.

A portion of the previous model domain known as "Eldredge Draw" will be eliminated. This was the northward projection along the northern margin of the model just east of the Millsite. The north end of the draw was specified as a general head boundary. The feature was a source of instability in the previous model. Seepage from north to south in the draw is perennial and believed to recharge the alluvial aquifer. The general head boundary condition will therefore be preserved but it will be placed further south and the cells in the draw will be deactivated. There are no wells in the draw.

Grid

Cell size will be reduced from 50 ft x100 ft (northing by easting) to 50 ft x 50ft. This will improve head resolution. The grid may be further refined in the area encompassing the contaminant plumes or the PeRT wall area.

Upper Surface

The model will have an upper ground surface that corresponds to the most recently surveyed ground surface or the planned surface that is available when model construction begins during Fall 2000. This is particularly relevant for the Millsite and peripheral properties immediately east of the Millsite. The upper surface does not influence the model solution, however, an accurate ground surface is a convenient for recognizing flooded areas (wetlands) and depths to ground water.

Bottom Surface

A new bottom surface will be defined using new bedrock elevation data from survey control on the Millsite and from borehole data obtained since RI. This data will complement data used to develop the bottom surface in the previous model. A grid-based contouring computer program will be used to interpolate the bedrock elevation between control points.

Hydraulic Conductivity

Hydraulic conductivity zones will probably be reassigned on the basis of the new information. This is especially true for the Millsite, where large quantities of imported fill will replace native materials. Data used to assign conductivity zones will include IRA pumping test results (native and imported fill will be tested), field observations, (e.g., very coarse alluvium was exposed in the PeRT wall test pit and Millsite excavations), and previous aquifer pumping and slug tests at the site. A minimum number of conductivity zones will be specified initially to account only for known material types and locations. A mid-range value from test data will be used as a starting point for native materials. The model will not be over-calibrated using conductivity zones.

PeRT Wall

The Pert Wall will be a permanent feature in the model domain. The dimensions and hydraulic properties of the gate and wall will be assigned based on construction specifications, laboratory performance tests, and field tests.

River Cells

Reconstruction of Montezuma Creek will require that a new alignment and new elevations be used in the model. As in the RI model, Montezuma Creek will be represented as an internal boundary using the MODFLOW River Package.

8.2.1.3 Calibration Targets

The following are identified as calibration targets for the flow model:

- 1) Steady state hydraulic heads after Millsite remediation is finished and the aquifer and creek are reconstructed. A single measurement event will be selected as the target.
- 2) Ground water flux to the Millsite from the west. Water balance calculations will be used to estimate underflow from the west. The calculations will be based on field measurements made on several occasions while the Millsite excavation was open. On those occasions, ground water discharge into the west end of the excavation was measured in discrete channels using the velocity-area method. Bucket and stop watch measurements were also made from outfall pipes between ground water collection ponds in the excavation and from seeps on the north hill slope. Stream discharge was also measured at several locations by the velocity-area method.
- 3) Ground water flux through the permeable section of the PeRT wall. Flux through the gate will be estimated using routine OU III monitoring data (hydraulic heads), gate dimensions, and additional data collected prior to and during PeRT wall installation. The additional data collection may include hydraulic tests to determine hydraulic conductivity, tracer tests to determine velocity, and use of thermal sensors or colloidal borescopes to determine velocity. Laboratory tests were conducted to determine saturated conductivity of the iron media during the design phase.
- 4) Model-predicted stream gain and loss will be compared to measured stream flows. This will be done qualitatively to ensure that the creek is not exaggerated as a source or sink in the model.

8.2.2 Contaminant Transport Modeling

Contaminant transport in the alluvial aquifer will be simulated numerically using the MT3D96 computer code. The contaminants that will be modeled are arsenic, uranium, and vanadium. These analytes were identified in the RI as the primary risk drivers at the site (DOE 1998c [Appendix L, Human Health Risk Assessment]). MT3D96 was designed for use with any block-centered, finite difference, 3-D flow model and predicts the effects of advection, dispersion, and chemical reaction during contaminant transport in ground water. MT3D will be used deterministically. A parallel transport model will be developed using stochastic methods.

8.2.2.1 Transport Model Conditions

Initial Contaminant Concentrations

The starting contaminant concentrations in ground water will be assigned from sampling results obtained from a single event that occurs after the ground water system has stabilized. Transport will be simulated separately for each analyte. A grid-based surface contouring program will be used to interpolate and assign starting concentrations for each cell between the sampling points. The minimum starting concentrations will be equal to the background concentration for the respective analytes in the RI models.

Vadose Zone

Contaminants entering ground water from the sub-pile vadose zone will be represented in MT3D by assigning a concentration to the surficial recharge rate for each cell of the flow model. The recharge concentrations will be predicted using a 1-dimensional variably saturated flow and contaminant transport model, or will be set equal to the leachate concentrations measured in the column experiments. The experimental results will be normalized to site conditions so that model time and column time are equivalent. The initial conditions used in the predictive approach, such as initial dissolved concentration and Kd, will be derived from IRA data collection tasks. MT3D permits assigning recharge concentrations on a cell-by-cell basis and in multiple stress periods to account for spatial and temporal variability in surficial sources.

Contaminant Concentrations at Other Hydrologic Boundaries

In MT3D, a concentration must be specified for all hydrologic sources in the flow model. For the constant head and general head boundaries, river cells, and recharge areas not associated with the sub-pile vadose zone, specified concentrations will be equal to the background value. The only hydrologic sinks in the flow model will be effluent (gaining) river cells. Specifying a background concentration at effluent river cells does not negate mass removal from the aquifer; mass will be removed from the system at the concentration and volume of water entering the sink.

MT3D does not solve for surface water concentration. The mass that is removed at any hydrologic sink is not available to re-enter the system. It is therefore not possible for mass that was removed in a gaining stream section to enter the aquifer in a downstream losing reach without imposing an artificial concentration boundary in the losing reach. It is doubtful that this limitation will be significant to the OU III models because of extensive source removal during surface remediation. Surface water concentrations are now much lower than pre-remediation levels at many locations. Only if, after the aquifer and creek are reconstructed, surface water concentrations increase significantly above ground water standards or PRGs, will artificial concentration boundaries be considered in losing stream reaches. The losing stream reaches must be supported by field evidence. Otherwise, background concentrations will be specified.

Advection

The advective component of contaminant transport will automatically be represented in MT3D by the output from the steady-state flow model.

Chemical Reaction

Arsenic, uranium, and vanadium behave to varying degrees as reactive, non-conservative species in the vadose zone and ground water at the site. Column tests completed to date confirm the presence of leachable phases of these analytes in vadose zone and aquifer materials. In the MT3D transport models, chemical reaction will be represented as equilibrium controlled sorption. Values for Kd will be determined by the field and laboratory methods described in Section 5.0. It is anticipated that a single Kd per analyte will be assigned to the entire domain except the cells representing the reactive media of the PeRT wall. After the initial concentrations in ground water and the Kd are specified, MT3D calculates a mass of sorbed contaminant in each cell. Sorbed and dissolved phases are then available to repartition between ground water and solid substrate during model simulation as less concentrated water enters the system and contaminated water flows into previously uncontaminated regions. The initial total mass is conserved in the model unless lost at hydrologic sinks or through decay or degradation, which are not applicable to the site model.

Dispersivity

There currently is no site-specific data for aquifer dispersivity. Dispersivity will be estimated from the tracer test discussed in Section 6.0 if the data is amenable to such analysis. Aquifer dispersivity may also be estimated by comparing the ratio of column and aquifer flow velocities to dispersivity estimates from the aquifer column tests. The default values will be those used in the RI models, where dispersivity was treated as a calibration parameter. The effect of dispersivity on contaminant transport predictions will be evaluated by sensitivity analysis.

Model Calibration

The calibration targets for transport model calibration will be the monitoring results for the PeRT wall wells downgradient of the gate (Figure 6.1.1-1, wells R7-M1 to R11-M1). Predicted concentrations will be compared against the time versus concentration profile at the wells since they were first sampled in September 1999. No acceptance criteria are proposed. However, if a large discrepancy is observed between predicted and measured values, the cause will be determined and transport parameters (Kd and dispersivity) will modified if appropriate. Calibration will be attempted only for uranium and vanadium. Arsenic concentrations are too low in this area.

PeRT Wall

The PeRT wall will be represented as a permanent feature in the transport models. This will be done by specifying the reactive media cells as constant concentration cells or point-source concentration cells. The specified concentration for either case will be equal to the outflow concentration from the PeRT wall monitoring data. The gate cells will thus be solute sinks and mass will be removed from ground water to the specified concentration. A constant concentration cell is used in MT3D at a non-hydrologic boundary, and the concentration remains constant throughout a simulation. A point-source (-sink) cell can be used at any location in the active domain and the concentration can vary throughout a simulation.

The mass removed at a constant concentration or point-sink cell is not available to re-enter the ground water. Using a Kd to represent mass removal from ground water in the PeRT wall is not a valid approach because contaminants are immobilized by precipitation reactions. The contaminants are therefore not available for rapid, reversible desorption under the Kd approach.

8.3 Baseline Risk Assessment Reevaluation

The baseline risk assessment presented in the 1998 RI will be reevaluated using exposure point concentrations representative of post Millsite remediation surface water and ground water conditions and using the output of the ground water transport modeling for future exposure point concentrations. Human health and ecological exposure scenarios assessed will be the same as those presented in 1998 RI. For the human health risk assessment, Doe will review the Integrated Risk Information System (IRIS) database generated by EPA to determine if human health reference doses have changed since the 1998 RI report. Updated reference doses will be used in the reevaluation. For the ecological risk reevaluation, EPA has agreed to provide updated toxicity reference values to be used.

9.0 Feasibility Study

The draft FS (DOE 1998e) will be revised to incorporate changes in the surface water and ground water systems as a result of Millsite remediation and PeRT wall installation. The scope of the post-Millsite remediation FS will be based on technical discussion among DOE, EPA, and UDEO during the course of the IRA and will be summarized in a FS work plan. The FS Work Plan will list the remedial alternatives to be considered in the post-Millsite remediation FS as well as the methods and ground water modeling that will be used to evaluate them, and will present an updated analysis of applicable or relevant and appropriate requirements (ARARs). Prior to completing the FS Work Plan, DOE will develop preliminary remediation goals and present them to the regulatory agencies for review. Concurrence on the remediation goals and on remediation time frames will be achieved during the technical meetings and presented in the FS Work Plan. Data collection activities discussed in Section 5.0 may be tailored during the course of the IRA so that all necessary information is collected and analyzed prior to preparation of the post-Millsite remediation FS. Preparation of the post-Millsite remediation FS document will begin in the summer of 2003 approximately six months prior to the draft document submittal. Ground water modeling associated with remedial alternatives analysis will begin early in 2003 approximately six months prior to initiation of drafting the text for the FS. The FS will be prepared to satisfy the requirements of CERCLA, as amended by SARA, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

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10.0 Cost Summary

The current cost estimate for each fiscal year for completion of OU III through the ROD is shown in Table 10–1. FY 2000 funding is adequate for the scheduled activities. Funding has already been requested for FY 2001 which, if fully appropriated, will be adequate to fund the scheduled activities. Cost estimates presented for FY 2002 and the out years are DOE's current budget request. Other than the State Grant Cost, there exists flexibility in moving funding between the subtasks.

Table 10-1 Operable Unit III Funding Levels

Subtask	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05
Project Management	144,762	131,076	148,953	148,953	148,953	188,650
Feasibility Study	65,503	59,170		166,744	183,711	0
Annual Monitoring	374,176	358,932	348,944	348,944	334,132	294,886
Interim Remedial Action	338,639	284,863	422,588	101,642	0	0
PeRT Wall	217,446	0	0	0	-0	0
Proposed Plan	0	0	0	0	42,852	24,802
Record of Decision	0	0	0	0	0	73,019
Contingency	0	0	0	0	0	281,250
State Grant Cost	0	0	150,000	150,000	150,000	150,000
Escalation @ 2.7 percent for 2000 and 2.1 percent per year	29,985	40,507	75,555	85,262	99,723	141,193
Total	1,170,511	874,548	1,146,040	1,001,545	959,371	1,153,800

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11.0 Interim Remedial Action Reporting and Documentation

A combination of informal data transmittals, annual status reports, annual monitoring reports, and stipulated penalty milestone primary documents will be used to document progress on the IRA. In addition, the CERCLA 5-Year Review report will contain information on some OU III, IRA activities. The reporting and documenting mechanisms for each of the IRA activities covered in Sections 3.0 through 9.0 of this document are discussed below.

Institutional Controls

DOE will conduct annual site inspections in October of every year to ensure that the institutional controls are working. The results of these inspections will be presented in annual IRA status reports submitted in August and in the CERCLA 5-Year Review report.

Dewatering and Treatment

Data regarding contaminant mass reduction in the alluvial aquifer through dewatering and treatment activities is presented in Section 4.0 of this document. This information will also be presented in the annual status report prepared in August 2000 and may be used in the post-Millsite remediation FS to assist in the evaluation of remedial alternatives for OU III.

Data Collection

IRA tasks for OU III consist largely of data collection and analysis. Analytical results from soil and water sampling will be stored in a data base that is easily accessed by the data users. Surface water and ground water analytical results will be transmitted to the regulatory agencies in annual surface water and ground water data summary reports. Tabulated results obtained from other tasks such as the results of soil sampling and column studies will be submitted to EPA and UDEQ prior to quarterly scheduled technical meetings. Tabulated results of soil analyses will also be included in the annual IRA status report along with a summary of progress made in performing data collection activities.

The addendum to the RI report will contain a description of all data collection tasks, results, and interpretation along with a description of the ground water modeling effort and the reevaluation of human health and ecological risk. The addendum to the RI report will be submitted as a primary document and will include analytical data collected through January 2003. A submittal date of August 30, 2003 for the draft RI addendum is proposed.

PeRT Wall

Tabulated results from the sampling of PeRT wall performance monitoring wells and water level maps will be submitted to EPA and UDEQ prior to the quarterly scheduled technical meetings. The results will also included in the annual surface water and ground water data summary reports. An Evaluation of the PeRT Wall Treatability Study Report will be submitted as a primary document with a stipulated penalty milestone submittal date of September 30, 2002. The PeRT wall will also be evaluated as a remedial alternative in the post-Millsite remediation FS submitted in May 2004.

· Surface Water and Ground Water Monitoring

Surface water and ground water analytical results from each fiscal year will be submitted to the regulatory agencies in a surface water and ground water data summary report prepared in the first quarter of the subsequent fiscal year. The results will also be presented in the addendum to the RI.

Addendum to the RI Report

The RI Report Addendum will contain a summary of the IRA data collection efforts, ground water modeling, and a reevaluation of human health and ecological risk as discussed in Section 8.0. The RI Report Addendum is a primary document; the proposed date for submittal of the draft document is August 30, 2003.

Feasibility Study

It is anticipated that the details regarding the scope of the post-Millsite remediation FS will be discussed in the quarterly meetings among DOE, EPA, and UDEQ. Issues that should be resolved include preliminary remediation goals, remediation time frames, and the range of remedial alternatives to be evaluated. An FS Work Plan will be prepared to formalize agreement on these issues and will also include an updated analysis of ARARs. The preliminary evaluation of ARARs presented in the draft FS (DOE 1998e) will also be reviewed and updated in the annual IRA status reports beginning in 2000 and in the post-Millsite remediation FS.

The draft final OU III FS submitted in May 2004 will contain all standard elements of an FS and will be prepared to satisfy the requirements of CERCLA as amended by SARA and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

12.0 Schedule of Activities

Listed below are the major activities that will occur and documents that will be prepared leading up to the record of decision for OU III. Primary documents include this IRA Work Plan, the FS Work Plan, the evaluation of the PeRT Wall Treatability Study, the addendum to the RI, the FS, the Proposed Plan, and the Record of Decision. Another primary document is the CERCLA 5-Year Review report, which although emphasizing OU I and OU II activities, will cover some OU III activities. All other documents are considered secondary documents. Figure 12–1 shows the timing of OU III activities as compared to Millsite activities. In addition, DOE intends to have quarterly meetings with EPA and UDEQ during which results of recent data gathering efforts and the technical aspects of planned activities are discussed.

Annual Interim Remedial Action Status Report

August (yearly)

Administrative Record Updates

Updates quarterly
 Final Update (begin Information Repository)
 6/15/2005

CERCLA 5-Year Review reports

2/13/2002 (every five years)

Institutional Controls

Institutional Controls implemented
 Annual Site Inspections
 Reporting in annual IRA status reports
 Reporting CERCLA 5-Year Review reports
 Site Inspections
 August (yearly beginning in 2000)
 2/13/2002 (every five years)

Data Collection

•	Sub-pile and Off-Pile Soil Sample Collection (Task 1)	11/98 to 1/00
•	Column Tests (Task 2)	3/99 to 4/00
•	Lysimeter Installation and Testing (Task 3)	8/01 to 1/03
•	Millsite Creek Corridor Backfill Characterization (Task 4)	3/00 to 12/00
•	Aquifer Recharge Estimation (Task 5)	3/01 to 5/02
•	Temporary Well Installation and Monitoring (Task 6)	6/99 to 12/00
•	Permanent Well Installation (Task 7)	10/00 to 10/02
0	Aquifer and Backfill Materials Sample Collection (Task 8)	3/00 to 12/02
0	Column and Batch Tests (Task 9)	10/00 to 1/03
•	Select New Millsite Surface Water Sampling Locations (Task 10)	9/00 to 7/01
0	Aquifer Testing (Task 11)	3/01 to 12/02

PeRT Wall Treatability Study

Performance Monitoring (Task 1)
 Ground Water Monitoring
 Reactive Media Tracer Testing

9/99, 10/99, 11/99, and then quarterly 5/00

Slurry Wall Performance Testing (Task 2)
 Water Level Measurements
 Tracer Testing and Monitoring

9/99, 10/99, 11/99, and then quarterly Beginning 2/00 Weekly monitoring September 30, 2002

Draft Final Evaluation of PeRT Wall Treatability Study

Surface Water and Ground Water Monitoring

0	Surface Water and Ground Water Monitoring	quarterly (yearly)
•	Surface Water and Ground Water Data Summary Report	December (yearly)

Documents

٥	Draft Final Post-Remediation Feasibility Study Work Plan	1/15/2002
	Draft Final Remedial Investigation Addendum	1/15/2004
•	Draft Final Post-Millsite Remediation Feasibility Study	5/14/2004
0	Draft Final Proposed Plan	12/15/2004
	Draft Final Record of Decision	5/15/2005

Document Number Q00149AD

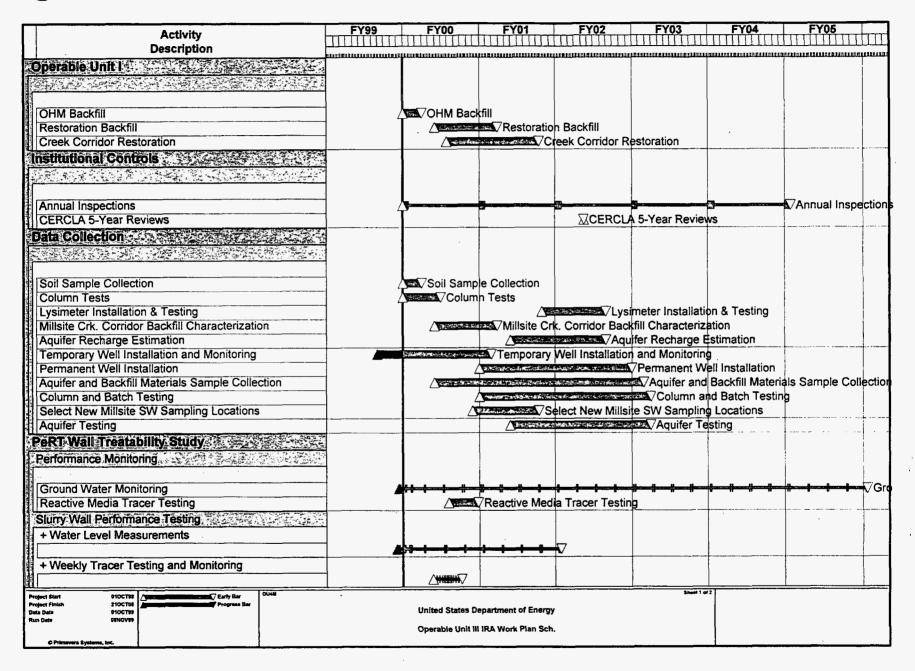
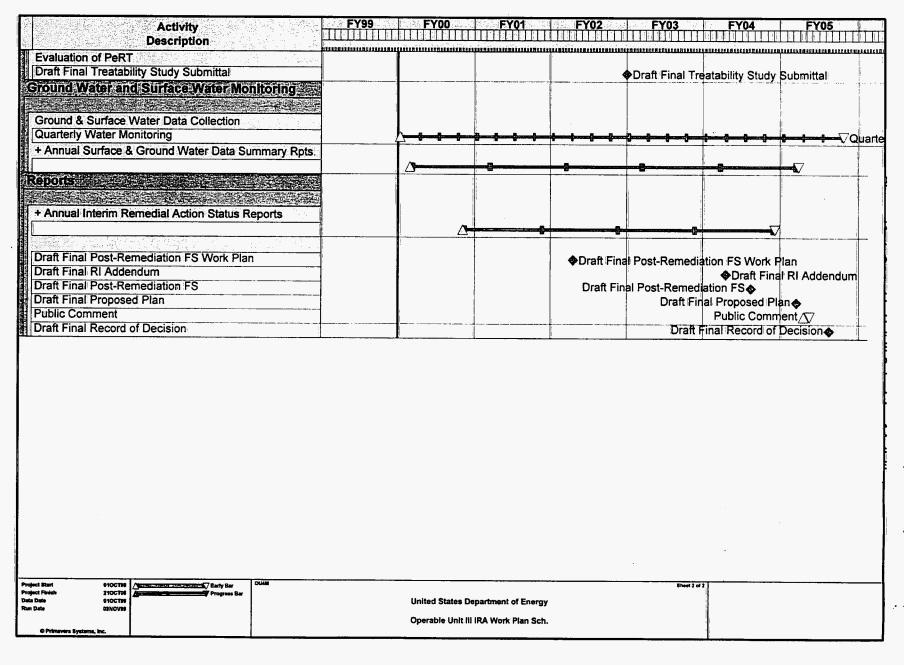


Figure 12-1. Operable Unit III Schedule of Activities

Document Number Q00149AD





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Appendix A

Ground-Water Management Policy for the Monticello Mill Tailings Site and Adjacent Areas This page intentionally blank



Michael O. Leavitt Governor Ted Stewart Executive Director Robert L. Morgan State Engineer

State of Utah DEPARTMENT OF NATURAL RESOURCES DIVISION OF WATER RIGHTS

1594 West North Temple, Suite 220 Box 146300 Salt Lake City, Utah 84114-6300 801-538-7240 801-538-7467 (Fax)

Ground-Water Management Policy for the Monticello Mill Tailings Site and Adjacent Areas

The Monticello Mill Tailings Site is on the southeast portion of the town of Monticello in Section 36, T33S, R23E and Section 31, T33S, R24E, SLB&M. The mill site was used from 1942 to 1960 in the processing of uranium and vanadium. The U.S. Department of Energy (DOE) is currently cleaning up the site. The site is in the small canyon that forms the drainage for South Creek. The general direction of water flow, of both surface streams and the shallow ground water system is in a southeasterly direction. The geology of the site consists of about ten to 30 feet of alluvial fill material underlaid by Mancos Shale or Dakota Sandstone. The former mill site area was heavily contaminated and there has been some movement of the metals and radionuclides down gradient.

The U.S. Department of Energy, with oversight from the Environmental Protection Agency and Utah Department of Environmental Quality, has conducted extensive sampling and testing of the site and adjacent areas. They have determined that at the present level of contamination it could pose a significant human health risk if they ingest the water. DOE submitted a request to the State Engineer to apply institutional controls for the site to restrict the development and use of the shallow ground water for domestic purposes.

The State Engineer has reviewed the data and information related to the Monticello Mill Tailings Site and believes there are potential human health concerns. The area of concern is the shallow alluvial fill aquifer at and immediately east of the Monticello Mill Tailings Site. Therefore, the State Engineer adopts the following ground-water management policy.

- 1. The area covered by this ground-water management policy is shown on attachment number 1, and hereafter referred to as the Monticello Ground-Water Restricted Area.
- 2. New applications to appropriate water will not be approved which propose to divert and use water for domestic purposes from the shallow alluvial fill aquifer within the boundaries of the Monticello Ground-Water Restricted Area. In addition, change applications will not be approved which propose to divert and use water from the shallow alluvial fill aquifer for domestic purposes

Monticello Mill Site - Page 2

- 3. Several existing water rights divert and use surface or ground water within the restricted area. This management policy, and any restrictions or limitations it may impose, does not affect these existing water rights as they now exist. If actions are necessary to curtail water use under existing water rights they will be handled under individual agreements between the parties.
- 4. If a water user requests permission to drill a well into the deeper bedrock formations within the restricted area, they will be required to demonstrate that they can seal out the shallow contaminated ground water and not allow the flow of water between the shallow alluvial aquifer and the deeper bedrock aquifers/formations.
- 5. The above controls will remain in effect until it is determined that the risk to human health is eliminated or reduced to acceptable limits.
- 6. The effective date of this policy is May 21, 1999.

Robert L. Morgan, P.E.

State Engineer

If you have questions about this policy, contact a Division of Water Rights office listed below:

Division of Water Rights 453 South Carbon Avenue

P.O. Box 718

Price, Utah 84501-0718

Phone: 435-637-1303

Fax: 435-637-7937

Division of Water Rights 1594 West North Temple

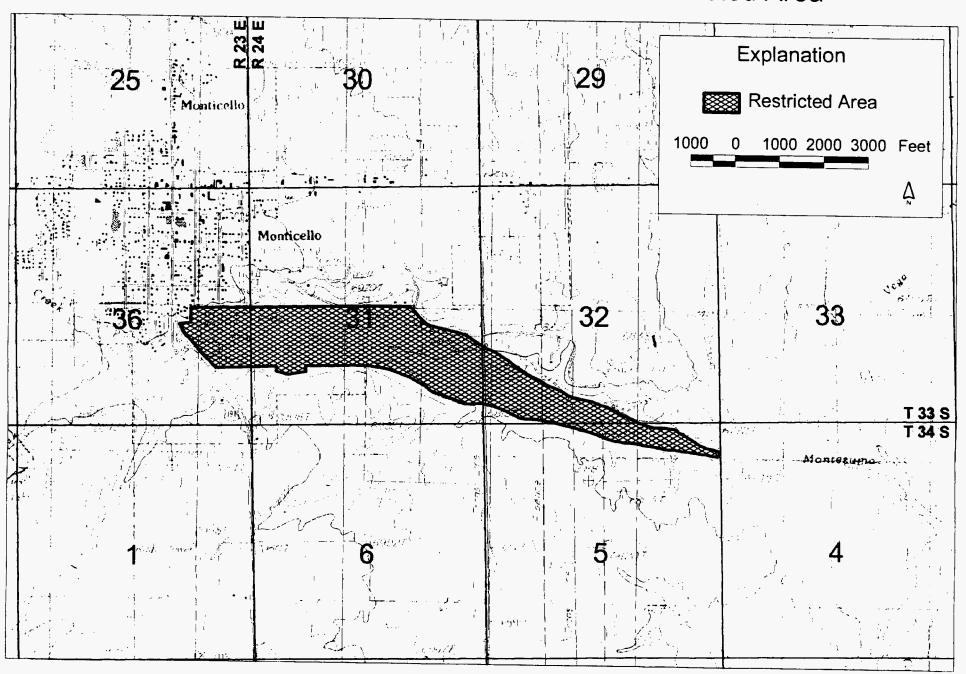
Box 146300

Salt Lake City, Utah 84114-6300

801-538-7240

801-538-7467

Attachment 1 - Monticello Ground-Water Restricted Area



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Appendix B

Uranium Removal During Millsite Dewaterting

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MMTS OU III IRA Work Plan, November 1999

Problem Statement

Estimate the mass of uranium removed from the ground water system during millsite dewatering and treatment.

Method of Solution

Method 1

- [1] Visually estimate a mean concentration in millsite ground water from the October 1995 uranium plume map in the RI.
- [2] Multiply the mean concentration by the total volume of water treated at the WWTP (5.4E+07 gal).
- [3] Assume that one-half of the total volume treated was from ground water, and recompute.

Method 2

- [1] Multiply treatment volume (5.4E+07 gal) by concentrations of influent water samples and excavation water samples.
- [2] Assume that one-half of the total volume treated was from ground water, and recompute.

Method 3

- [1] Use draft FS flow and transport model results for alternative PA8A (see Appendix E, Calculation Q00074AA). This is an active restoration scenario with 20 extraction wells in the millsite plume. The combined extraction rate was 38 gal/min.
- [2] Assume that millsite dewatering during surface remediation removed 1 pore volume of the uranium plume.
- [3] Determine the pore volume of the uranium plume (>=30 pCi/L) on the millsite. This was by the same method used to estimate the entire uranium plume volume in the draft FS (see Appendix E, Calculation Q00077AA), except that the present calculation was limited to the millsite. An annotated copy of the volume calculation is attached.
- [4] Determine the time to remove 1 pore volume from the plume in the PASA model.
- [5] Use mass budget output for model PA8A (see Appendix E, Calculation Q00078AA) to extrapolate the mass of uranium removed at 1 pore volume. Graphical display of mass removed by extraction wells in model PA8A is attached:

Calculation

Method 1					
Volume	Influent Conc.	Mass Uranium			,
Treated [L]	[U, mg/L]	Removed [kg]			
2.0E+08	0.75	150	total mass removed	from ground water	er system
1.0E+08	0.75	75	mass removed from	aquifer	•
Method 2					
Influent Conc.	Total Volume	Mass Uranium	Volume Ground	Mass Uranium	
[U, mg/L]	Treated [L]	Removed [kg]	Water Treated [L]	Removed [kg]	
0.109	2.0E+08	22	1.0E+08	11	09/15/98 Carbonate Pond [lab no. 254470]
2.67	2.0E+08	534	1.0E+08	267	09/22/98 East Pond [lab no. 254714]
0.518	2.0E+08	104	1.0E+08	52	10/29/97 Pond 3 influent [ticket no. NDA920]
2.47	2.0E+08	494	1.0E+08	247	08/18/97 Carbonate Pond [lab no. 246165]
0.372	2.0E+08	74	1.0E+08	37	10/14/97 Pond 3 influent [ticket no. NDA872]
0.484	2.0E+08	97	1.0E+08	48	10/16/97 Pond 3 influent [ticket no. NDA893]
0.53	2.0E+08	106	1.0E+08	53	10/23/97 Pond:3 influent
Method: 3			Mass Uranium	Mean Conc.	
Extraction Rate [L/yr]	Pore Volume [L]	Time at 1 PV [yr]	Removed [kg]	Removed (U. mg.	/L)
7.6E+07	1.0E+08	1.35	75	0.73	•

volcalc.txt

VOLUME COMPUTATIONS: Uranium plume >= 30pCi/L on Monticello Millsite All dimensions in feet.

UPPER SURFACE - avg. water table elev. w/in 30 pCi/L uranium contour on millsite.

Grid File: F:/HOME/T50802/WINSURF6/OU3/REMSURF/OUT.GRD

Grid size as read: 489 cols by 99 rows

Delta X: 50

Delta Y: 49.7449

X-Range: 15200 to 39600 Y-Range: 4185 to 9060

Z-Range: 6801.27 to 6868.83

LOWER SURFACE - bedrock surface w/in 30 pCi/L uran contour on millsite

Grid File: F:/HOME/T50802/WINSURF6/OU3/REMSURF/BRELBLN.GRD

Grid size as read: 489 cols by 99 rows

Delta X: 50

Delta Y: 49.7449

X-Range: 15200 to 39600 Y-Range: 4185 to 9060

Z-Range: 6690.96 to 6856.36

VOLUMES

Approximated Volume by

Trapezoidal Rule: 1.19125E+007

Simpson's Rule: 1.19211E+007

Simpson's 3/8 Rule: 1.19002E+007

CUT & FILL VOLUMES

Positive Volume [Cut]: 1.20152E+007

Negative Volume [Fill]: 102748 Cut minus Fill: 1.19125E+007

AREAS

Positive Planar Area

(Upper above Lower): 1.21763E+006

Negative Planar Area

(Lower above Upper): 25996.6

Blanked Planar Area: 1.17706E+008 Total Planar Area: 1.1895E+008

Positive Surface Area

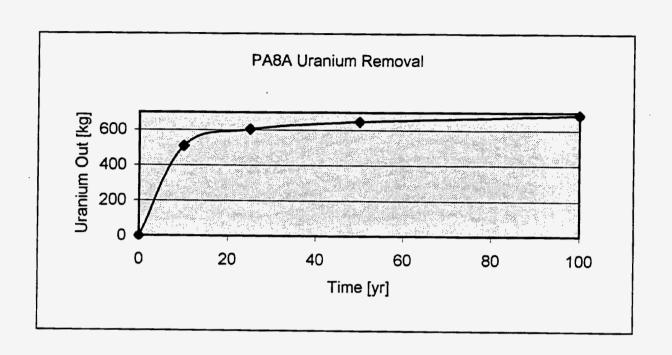
(Upper above Lower): 1.21961E+006

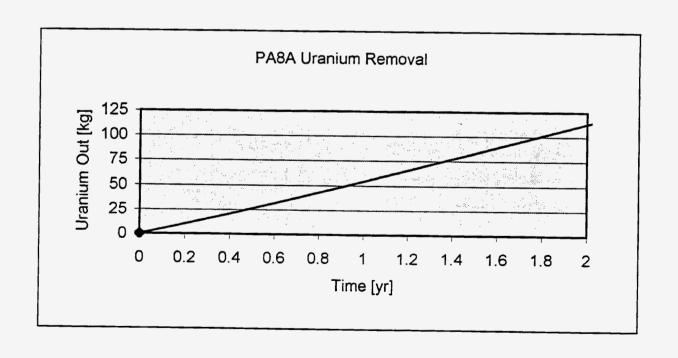
Negative Surface Area

(Lower above Upper): 26111.3

Total volume between upper and lower surface in bounded region = 1.2E+07 ft3.

Volume of ground water in region = total volume x porosity = 1.2E+07 ft3 x 0.3 = 3.6E+06 ft3 = 2.7E+07 gal = 1.0E+08 L

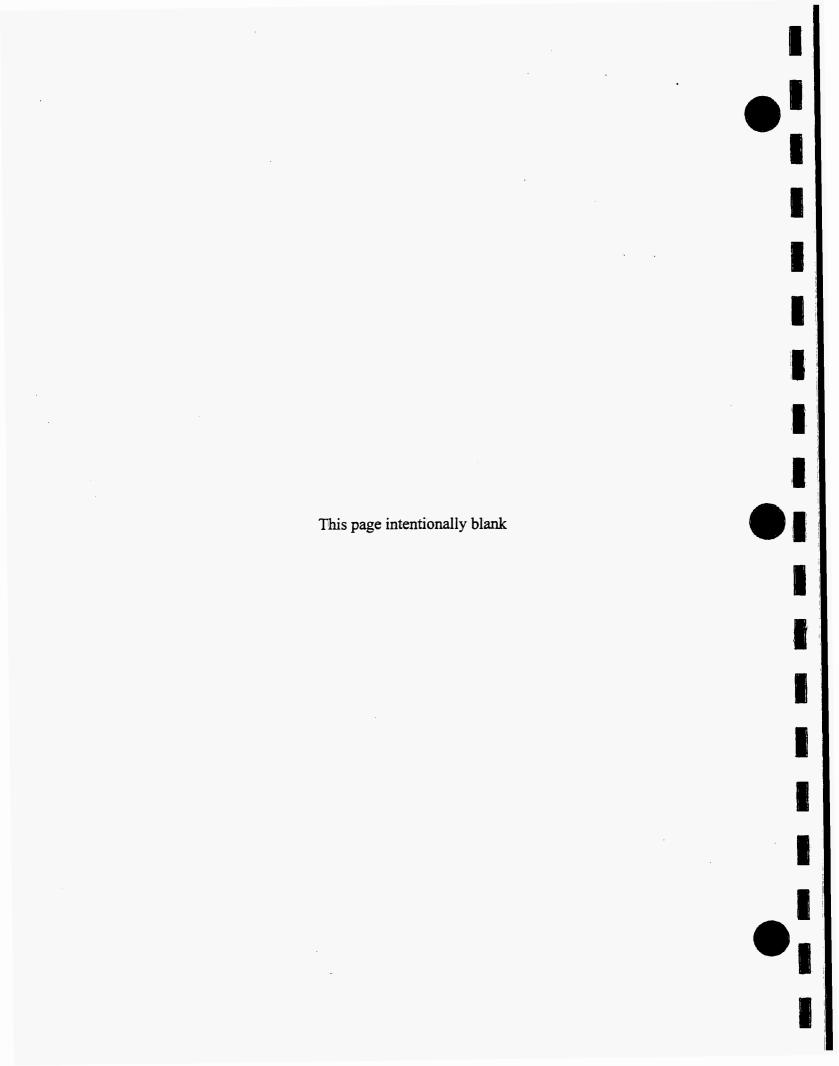




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Appendix D

Response to Comments for the Monticello Mill Tailings Site, Operable Unit III, Interim Remedial Action Sampling and Analysis Plan, Phase I



1. Page 1-1, Section 1.0 Introduction, first paragraph, third sentence: This sentence includes a reference to "vadose zone source term" at the end of the sentence. Please move this to the middle of the sentence immediately after "contaminants from the vadose zone," as the sentence is more coherent this way.

Response: Text revised as suggested.

Page 1-1, Section 1.0 Introduction, first paragraph, last sentence: Please update the
reference to the Feasibility Study, as the next version will be after Millsite restoration is
complete.

Response: Text revised to state that the remedial alternatives will be evaluated under a "revised Operable Unit III Feasibility Study for Surface Water and Ground Water which will be completed in 2004."

3. **Page 1-2, Section 1.2 Schedule:** DOE should elaborate on the question of whether the data collection and modeling will be complete in time to make a decision about excavating additional quantities of soil before the planned cell closure.

Response: The following text has been added, "A decision to excavate additional quantities of soil at the Millsite, beyond that needed for Millsite verification, will be made after considering column study results, calculations of future ground water concentrations, and available capacity at the repository. The column studies are scheduled to be completed and calculations performed in time so that this decision can be made prior to the last scheduled date for tailings placement in the repository."

4. Page 2-2, Section 2.1.4 Laboratory Analysis, first sentence: Please describe how the method which will be used for pH analysis of soils is a standardized, commonly accepted methodology.

Response: The text has been revised to state that laboratory procedures used for analysis are standard EPA methods.

5. Page 2-3, Section 2.2.1 Data Objectives, second paragraph, last sentence: Please note here that extrapolation of distribution coefficients from published sorption isotherm models and the use of flow and transport modeling assumes that sorption and desorption processes and their kinetics are equal, which may not be the case.

Response: The reviewer's comment is correct. Additional tests are now included that will determine whether slow desorption kinetics are occurring. Flow to two of the columns with highest contamination will be discontinued and then after 1 day restarted. If significant increases in concentrations are observed after the restart, it will be concluded that desorption kinetics need to be considered. Sections 2.2.1 and 2.2.4 were amended to reflect this modification.

6. Page 2-4, Section 2.2.2 Geochemical Setting, first paragraph of page, fourth sentence: The text states here that the pH of distilled water quickly increases from 7 to 8.5 when mixed with soil collected at the site. Please discuss which soil minerals contribute to this alkalinity. Please include mineralogical analysis results to support this discussion.

Response: No mineralogical analyses have been performed. It is uncertain what processes contribute to the increase in pH. Equilibration with carbonate minerals and/or adsorption of protons to common silicate minerals is suggested as the cause. The text in section 2.2.2 was amended.

7. Page 2-4, Section 2.2.2 Geochemical Setting, third paragraph of page, first sentence: Please evaluate the effects of oxidation-reduction for arsenic and uranium in the proposed column testing, since they are redox sensitive and two of the main contaminants of concern. Please explain and justify why redox processes have not been included within the scope of the proposed study.

Response: It is most likely that the subpile system will remain oxic because it is shallow and contains low concentrations of organic matter. If the system were to become anoxic, the uranium and arsenic would probably precipitate as reduced minerals and the aqueous concentrations would become low (therefore the assumption of oxidation is conservative). A sentence was added to section 2.2.2 to indicate that minerals will precipitate under anoxic conditions.

8. Page 2-5, Section 2.2.3 Scope: Please discuss the criteria for selecting the sub-pile locations for soil samples. Criteria such as whether the locations are biased high or low for contaminant concentrations, and how many locations are required to be representative should be addressed. Please provide justification for the number and location of sampling points and how these are representative of the site.

Response: Reference Visual Sample Plan (a computer program developed by Oak Ridge National Laboratories to select sample locations on a quasi-random basis) was used to designate 330 grid blocks on the Millsite for surface soil sample collection. Sixty-three of these grid blocks were chosen for sample collection from the 2 to 3 ft depth interval. Of the 63 samples, 56 were chosen in sub-pile areas and 7 were chosen in off-pile areas. Sample numbers were biased toward sub-pile locations because 1) sub-pile areas account for most of the area on the Millsite, 2) these areas are more likely to show higher than background concentrations of contaminants in the subsurface, and 3) because they are more likely to show variation in contaminant concentration levels. Off-pile areas are expected to show concentrations of contaminants very near to background. Sub-pile sample locations were chosen to achieve a somewhat even distribution in areas where remediation was not anticipated to extend to bedrock or below the water table.

Sample collection was also designated from the 4-5 ft and 6-7ft depth intervals at 28 of the 2-3 ft sub-pile subsurface locations. Of the 28 locations, 9 are in the area of the

former Carbonate Pile. Most of the excavation in this area extended below the water table and a sizeable portion of the area was remediated to Dakota Sandstone bedrock. Six of the 28 locations are in the former Vanadium Pile area, six are in the former East Tailings Pile area, five are in the former Acid Pile Area, and two are in an Off-Pile area. Except in the Acid Pile area, the locations were again chosen to achieve a somewhat even distribution and are not anticipated to biased high or low. In the Acid Pile area, locations were prioritized in the northern half of the pile where saturated alluvium was present during the Remedial Investigation and where higher concentrations of contaminants in the ground water were measured.

Surface soil analytical results received to date were statistically analyzed to determine the number of measurements needed (assuming a normal distribution of the data) to characterize the uranium concentrations in the sub-pile and off pile areas. Uranium was chosen because it contributes the largest percentage to the risk associated with the site. Assuming that a variance of 5 ppm² is acceptable, five samples each are required to characterize the off-pile and vanadium pile areas and nine samples are required to characterize the carbonate pile area. Assuming that the variance is no greater at the Acid Pile than at the other piles, between five and nine samples are required there also.

Statistical Calculation:

Statement of the Problem: Estimate the number of samples necessary to adequately characterize each sub-pile area and off-pile areas.

Method:

Using a prespecified variance $V = 5(ppm)^2$ (from Gilbert 1987 pp 30)

$$n = \frac{s^2}{V} \left(1 + \frac{2}{n_1}\right)$$

where:

n = total number of samples to take

 $n_l = number of initial measurements$

 s^2 = standard deviation squared

V = variance (specified)

Vanadium Pile

$$n_1 = 27$$
 $\bar{x} = 9.5 \text{ mg/kg}$ $s = 4.4$
 $n = \frac{19.7}{5} (1 + \frac{2}{27}) = 4.23 \approx 5 \text{ samples}$

Carbonate Pile

$$n_1 = 40$$
 $\bar{x} = 8.95 \text{ mg/kg}$ $s = 3.8$
 $n = \frac{14.44}{5} (1 + \frac{2}{40}) = 3.03 \approx 4 \text{ samples}$

East Pile

$$n_1 = 45$$
 $\bar{x} = 12.8 \text{ mg/kg}$ $s = 8.4$
 $n = \frac{71.4}{5} (1 + \frac{2}{45}) = 14.9 \cong 15 \text{ samples}$

Off-Pile—Ore Storage Area

$$n_1 = 25$$
 $\bar{x} = 15.4 \text{ mg/kg}$ $s = 7.5$
 $n = \frac{55.9}{5} (1 + \frac{2}{25}) = 12.1 \approx 13 \text{ samples}$

Off-Pile—Other

$$n_1 = 26$$
 $\bar{x} = 8.35 \text{ mg/kg}$ $s = 3.5$

$$n = \frac{12.1}{5} (1 + \frac{2}{26}) = 2.6 \approx 3 \text{ samples}$$

The numbers of locations planned for surface soil sampling is sufficient (or expected to be sufficient) in all sub-pile and off-pile areas. Assuming that the variability in uranium concentration does not increase with depth, the numbers of locations planned for subsurface soil sampling is sufficient (or expected to be sufficient) in all sub-pile areas. Results from the planned sampling will be statistically analyzed to determine if additional depth sampling is required.

9. Page 2-5, Section 2.2.4 Experimental Design, first sentence: Please include ESL in the list of acronyms or define here.

Response: The acronym ESL has been deleted from the text and replaced with the words Environmental Science Laboratory.

10. Page 2-6, Section 2.2.4 Experimental Design, Stock Solution for Desorption Tests (surface water), second paragraph: Please discuss and provide information about what data was used to justify the formulation of the stock solution to simulate Montezuma

Creek water. Please disclose the number, identity, and concentration of bases that contribute to the reported surface water alkalinity.

Response: The plan will be amended to reference the analytical results of surface water samples collected at location SW92-01 during the OU III remedial investigation and during subsequent annual monitoring. The analytical results are documented in the MMTS Remedial Investigation, Volume II, Appendix C-1, September 1988; and in the MMTS OU III Data Summary Report, October 1996 – April 1998, November 1998. The values of the major ion chemistry and pH from the sample collected in October 1995 will be used to formulate the stock solution. Analyte concentrations and pH for that sample are generally within maximum and minimum values detected at that location. The text will also be modified to indicate that surface water alkalinity is assumed to be entirely attributed to dissolved carbonate species. This is a valid assumption for almost all natural waters except in rare cases where waters of unusual composition may have noncarbonate contributors to alkalinity. The composition of Montezuma Creek water is not considered unusual and therefore the assumption is reasonable for this study.

Page 2-6, Section 2.2.4 Experimental Design, Apparatus and Test Conditions, second sentence: It appears that the residence time per pore volume will be approximately 12 hours. Please discuss the reaction time for the different contaminants of concern and explain how sufficient time is available in the column test experiments.

Response: The 12 hours was used because it seems like a reasonable residence time for water to have with the contaminated soils and it is reasonable to carry out experiments for that length of time. The most likely reaction that could significantly modify interpretations is a slow rate of contaminant desorption. Slow rates of desorption are possible due to the process of contaminants becoming more tightly bound to the sediment over time. As stated in the response to Comment #5, the Plan was modified to include tests to help determine if slow contaminant desorption is likely to affect the results.

12. Page 2-6, Section 2.2.4 Experimental Design, Apparatus and Test Conditions, last sentence: Please include discussion of how often pH, Eh, conductivity, and alkalinity will be monitored during the column testing.

Response: pH, Eh, conductivity, and alkalinity will be monitored at a minimum of every pore volume.

13. Page 2-6, Section 2.2.4 Experimental Design, Rising Water Table Scenario: Please provide reference to the ground water data which supports the stock solution formulation. In particular, please disclose the number, identity, and concentration of bases that contribute to the total alkalinity of the representative site ground water. Also, please provide the Eh values for site ground water and how the stock solution will compare.

Response: The plan will be amended to reference the analytical results of ground water samples collected upgradient of the Millsite during the OU III remedial investigation and

during subsequent annual monitoring. The analytical results are documented in the MMTS Remedial Investigation, Volume II, Appendix C-1, September 1988; and in the MMTS OU III Data Summary Report, October 1996 – April 1998, November 1998. Values of the major ion chemistry, alkalinity, and pH from the sample collected at upgradient well 92–05 during October 1995 will be used to formulate the stock solution for the rising water table scenario. The text will also be modified to indicate that ground water alkalinity is assumed to be entirely attributed to dissolved carbonate species. This is a reasonable assumption because alluvial ground water upgradient of the Millsite is not considered to have an unusual composition (refer to response 10). The plan will also be amended to provide reference to and values of Eh in alluvial ground water. The Eh of the influent stock solution will be measured during the column tests for comparison to ground water Eh values, which are typically about 70 to 200 mV (relatively oxidizing) in upgradient and Millsite samples.

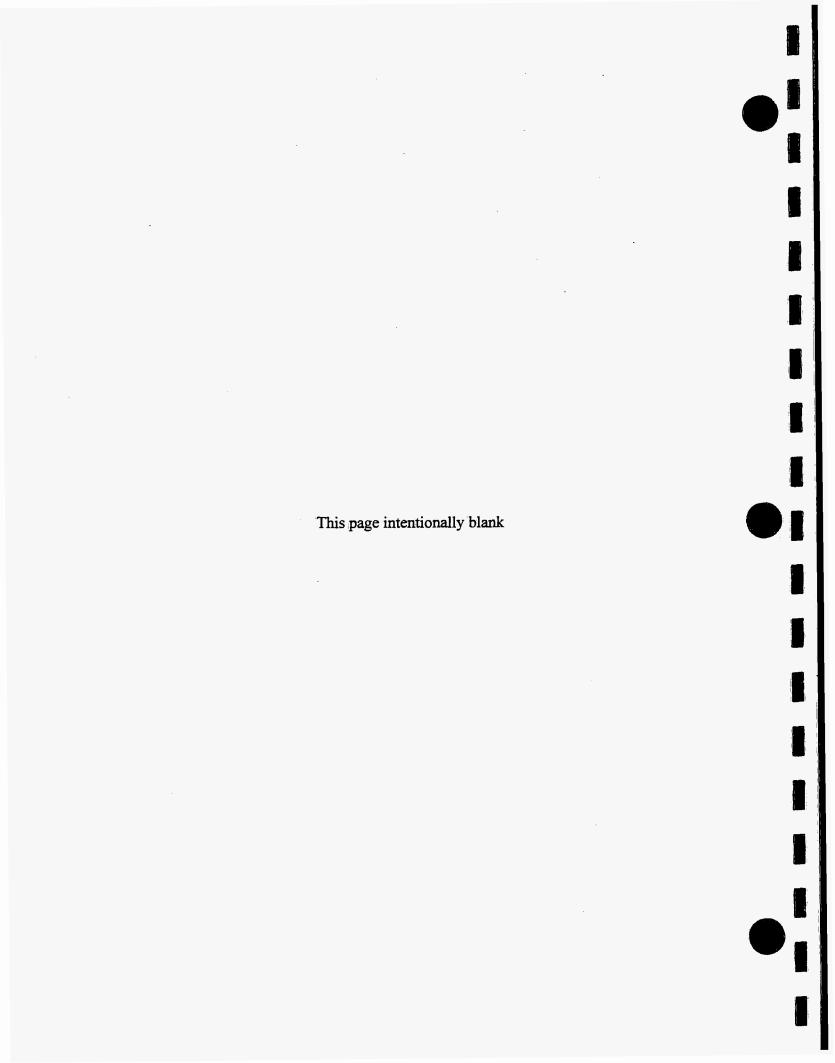
14. Page 2-7, Section 2.2.4 Experimental Design, Golf Course Scenario: For stock solutions with total alkalinity below 150 mg/L (CaCO₃), the addition of phosphate may pose the need to amend the alkalinity test (Standard Methods, Method 2320, 1989, p. 236). Please explain how such a difference will be accounted for, and any effect on comparability of alkalinity results.

Response: The standard procedure for measuring alkalinity when phosphate is present (or suspected) is to titrate to an end point pH of 4.5. For solutions with alkalinity of less than 150 mg/L the end point is specified as pH 4.6. These procedures will be followed.

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Appendix E

Ground-Water and Surface-Water Sample Results





Well	Collect	Alky	Ca	CDT	CI	DO.	Eh	F	K	Mg	Na	NH4	NO2	NO3	NO3+NO2-N	рН⊨	SO4	TDS	Temp	Turb
ld	Date	(ppm)	(mg/L)	(umhos/cm)	(mg/L)	(mg/L)	(mV)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	þΠ	(mg/L)	(mg/L)	(deg C)	(NTU)
92-01	11/12/1992	265	379	1336	9.93	4.96	210	~.119	~2.3	56.5	44.8	<20	<6.0	~31.8		6.48	940	1780	9.9	7.31
	03/08/1993	265		2150	10.8	5.60	233	~.122				36.0	<2.0	254		6.64	991	1830	8.9	23.9
	04/22/1993	308	408	2240	17.1	5.40	241	~.151	1.82	60.6	59	51.0	~5.3	3280		6.68	1020	1948	8.5	1.18
	07/20/1993	90	367	1883	13.1	4.65	139	~.149	~2.15	56.6	47.8	24.0	<8.0	20900		7.05	854	1624	8.8	2.51
	10/26/1993	288	517	2570	14.4	3.51	181	~ 183	~2.13	76.6	~64.8	30.2			4330	6.54	1200	2264	9.7	9.84
	05/02/1994	237	413	2250	11.9	5.40	154	~.0623	~2.1	66.5	53.1	58.8			730	6.37	1060	1940	8.3	2.14
	10/04/1994	303	456	2380	7.99	5.29	198	~.0775	~1.55	73	54.7	40.3			~155	6.52	1170	2280	9.7	4.84
	04/19/1995	270	386	2220	9.25	4.65	118	~.0344	~2.53	64.8	47.5	25.5			~128	6.89	1010	1900	8.1	3.84
	10/03/1995	294	509	2740	13.6	3.91	131	.242	~3.37	92	75.2	~13.8			3890	6.53	1430	2570	9.4	3.26
	10/28/1996	286	441	2290	6.53	3.95	80	.287	~2.66	71.6	47.8	~13.3			~40.3	6.97	1140	2060	8.9	3.56
92-03	11/12/1992	267	137	594	10.7			~.137	~2.84	17.6	34.2	80	~21.2	~364		6.84	186	600	10.7	8.37
	03/09/1993	308		887	9.82			~.13				48.0	~5.7	~191		7.00	164	555	7.2	>1000
	04/22/1993	211		590	6.84			~.157				45.0	~12.1	1260		7.21	106	~412	6.5	590
	07/26/1993	701		514	2.82			~.199				36.0	~9.0	365		6.85	70.8	~354	12.5	235
	10/27/1993	228		675	5.76	2.45		~.115				35.6			~41.8	6.89	102	~436	12.4	22.8
	04/26/1994	171		747	8.8	3.60	119	~.128				30.0			~61.0	7.18	136	~476	6.9	652
	10/04/1994	256	138	876	13	2.60	196	~.113	~2.1	18.7	29.2	145			~191	7.23	221	632	13.6	3.72
	04/19/1995	225		731	9.36	5.35	158	~ 0855				39.3			~35.6	7.32	140	~482	6.5	40.5
	10/04/1995	184		778	9	4.40	147	~.171				~19.0			~187	7.15	170	508	9:5	22.40
	10/29/1996	265		958	14.3	3.81	108	~.147				~8:9			~249	7.00	266	732	10.2	31.7
92-05	11/12/1992			976												6.59			9.3	105
	03/09/1993	290		833	9.06			~.154				60:0	~11.7	1750		6.80	187	548	4.8	651
	04/22/1993	372		1295	10.8			~.0866				21.0	~3.9	8040		6.59	418	990	7.9	233
	07/22/1993	178		1207	7.08			~.101				72.0	<8.0	5000		6.78	452	986	8.9	34.4
	10/26/1993	276	346	1868	10.7	6.48	198	~.114	~2.07	53.1	~43.2	49.0			1830	6.52	742	1534	9.5	5.65
	05/02/1994	214	291	1682	9.5	7.58	69	~.0827	~1.9	45.8	36.0	35.7			601	6.92	695	1350	7.4	3.52
	10/05/1994	324	258	1523	11.4	5.46	214	~.0536		41	38.1	87.0			2140	6.54	555	1160	9.3	3.10
	04/18/1995	225	225	1432	10.7	5.98	140	~.0477		35.2	31.6	25.5			~300	6.87	516	1070	6.6	3.08
	10/03/1995	287	248	1445	11.2	6.75	119	~.14	~2.8	39.8	38.8	21.6			~469	6.67	539	1130	14.6	2.63
	10/30/1996	289		1410	12.9	4.69		~.149				~13.3			180	6.82	450	1050	9.0	33.4
	10/13/1997	266	308	1670	14.7			~.148	2.64	44.2	43				738	6.87	679	1340	13.3	9.78
	10/05/1998	287	230	1402	13.6		124	~.132	~2.7	36.6	37.8				1040	6.95	495	1:100	11.1	15.7

Surface-Water Sample Results

Surface	Collect	Alky	Ca	CDT	CI	F	K.	Mg	Na	NH4	NO2	NO3	NO3+NO2-N	-11	SO4	TDS	Temp
ld	Date	(ppm)	(mg/L)	(umhos/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	įρΗ	(mg/L)	(mg/L)	
SW92-01	11/16/1992		356	1038	6.11	~.109	<1.7	38.7	26.3	34	<6.0	~81.3		7.70	848	1400	5.2
	11/16/1992		344		6.07	~.107	~2.28	38.9	26.4	36	<6.0	~55.2			836	1540	
	03/02/1993	206	329	1674	7.27	~.121	~2.56	35.5	~25.8	48.0	~8.6	~298		7.93	715	1340	4.0
	04/19/1993	212	403	1979	5.31	~.104	3.64	49.3	32.1	21:0	~30.2	~50:6		8.17	254	1826	13.1
	07/19/1993	113	96.4	602	2.49	~.0975	~1.59	13.5	8.39	71.0	~16.1	894		7.70	188	~414	11.5
	10/27/1993	179	431	2080	8.19	~.14	~3.41	58.3	~33.2	30.2			1580	7.84	1000	1842	9.6
	05/03/1994	215	388	1935	10.8	~.115	~2.8	50.3	26.9	61.7			146	8.24	927	1720	6.8
	10/05/1994	130	347	1733	4.62	~.123	~2.89	41.1	22.4	66.5			~90.4	7.96	816	1460	9.5
	04/17/1995	141	137	758	2.53	~.0844	~1.56	16	10.4	111			~28.0	8.33	282	580	8.8
	10/02/1995	235	380	1926	7.27	.289	~3.52	52.2	28.3	29.3			~323	7.83	958	1710	12.9
	06/26/1996		322		4.61	.231	~3.31	42.5	23.6				~11.3		782		
	06/26/1996		321		4.6	.231	~3.52	42.5	23.8				~15.1		788		
	10/21/1996	239	275	1492	4.48	~.187	2.82	34.8	23.1	~19.8			~82.4		614	1190	5.0
SW92-03	03/09/1993	233	109	751	9:01	~.13	<:917	14.3	~25.2	60.0	~6.2	600		7.89	142	483	3.8
	05/05/1993	137	102	682	5.42	~.104	~1.01	15.6	18.6	~22.0	~8.3	929		8.19	181	~454	4.1
	07/20/1993	114	98.4	659	2.84	~.0787	<.906	14.5	10.2	0.08	~8.5	1200		7.84	197	~450	10.1
	10/28/1993	166	331		-8	~.1	~2.1:1	46.7	~30	35.6			1040	7.99	739	1420	1.2
	10/28/1993		325		7.56	~.095	~2.76	46.3	~29.8	27.5			1010		734	1418	
	05/02/1994	220	200	1151	8.3	~.122	~2.7	29.1	25.8	96.3			~21.8	8.17	435	898	15.2
	10/05/1994	123	203	1192	4.76	~.127	~1.93	27	19.3	160			~84.1	8.24	474	914	9.8
	04/17/1995	170	104	692	7.1	~.0849		14.1	17.6	33.8			~15.4	8.42	199	506	8.1
	10/03/1995	201	340	1880	7.76	.202	~3.13	49.6	29.9	~19.0			~266	7.81	872	1560	5.8
	10/03/1995		341		7.74	.201	~3.68	49.6	30	52.5			~272		872	1540	
	10/21/1996	216	160	990	5.36	~.178	2.52	21.3	20	~15.4			~18.2		313	708	3.4
	10/14/1997	183	258	1386	6.16	~.195	2.56	34.2	23.1				233	8.15	579	1090	8.9
	10/05/1998	144	211	1212	4.27	.253	~2.68	29.6	18.4				~9.6	7.82	481	932	8.8
SW92-05	11/16/1992	302	352	1280	15.7	~.111	~4.7	61.7	66	53	~24.7	462		7.85	913	1760	7.4
	03/04/1993	261	264	1740	57.6	~.139	~3.56	50	~70.1	104	~33.1	3240		8.67	592	1350	6.2
	05/06/1993	168	131	901	10.8	~.0999	~1.27	21.8	28.2	23.0	~28.7	2960		7.56	254	630	5.6
	07/20/1993	123	120	800	5.52	~.0926		19.2	19.1	71.0	~16.4	2240		8.44	257	594	17.9
	11/02/1993	195	344	1940	12.3	~.125	~3.65	54.2	49.7	32:9			2010	7.87	795	1572	4.5
	05/05/1994	246	269	1609	13.5	~.0966	~2.2	44.4	41.8	64.6			827	8.06	638	1290	9.8
	05/05/1994	246	273	1609	13.4	~.0886	~2.4	44.9	43.0	61.7			902	8.06	640	1270	9.8
	10/11/1994	285	338	1871	12.3	~.0959	~3.45	51.9	51.5	51.9			~446	7.99	831	1540	6.5
	04/18/1995	214	218	1256	12.4	~.102	~2.1	33.3	35.5	61.4			837	8.20	480	1010	5.7
	10/05/1995	199	351	1981	10	~.156	~3.65	56.5	39.1	31.9			~443	8.30	908	1620	10.8
	10/05/1995		346		9.98	~.138	~3.56	55.9	38.8	31.9			~439		912	1650	
	04/10/1996	2267	324	1807	8.2	~.162	~2.15	51.4	38.2	192			~236	7.88	825	1500	5.5
	10/22/1996	321	335	1791	7.99	~.153	3.32	48.3	42.9	~17.6			~114	7.20	791	1490	8.1
	10/17/1997	222	303	1663	9.49	~.191	2.75	43.1	33.4				308	7.81	674	1320	6.6
	10/13/1998	151	203	1153	4.61	~.274	~2.76	29.1	19				~85.0	8.29	480	900	10.2

Appendix C

Calculations

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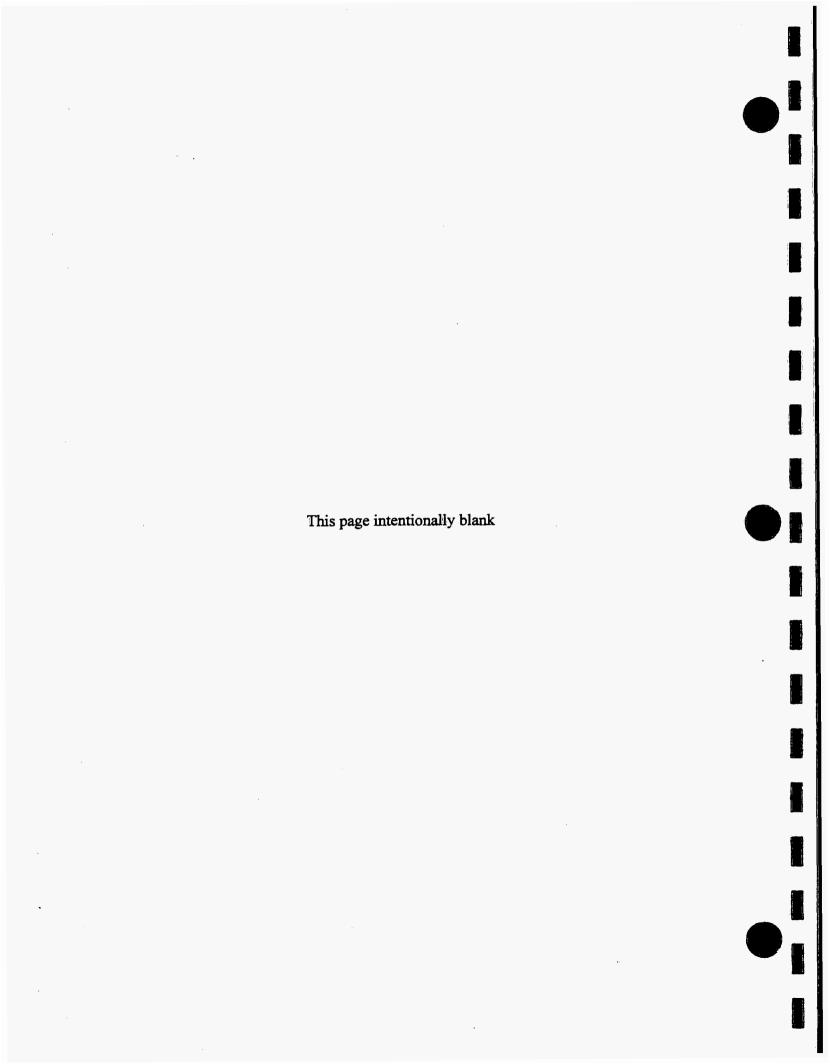
Contents

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Calculation Q00074AA, Model Results for Alternative 8A—Active Restoration A-13
Calculation Q00076AA, Initial Contaminant Mass in Aquifer
Calculation Q00077AA, Volume of Water in Uranium Plume
Calculation Q00078AA, Mass Removal and Treatment Volume —Alternatives 4, 7, 8A and 8B

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Total Groundwater Flux to Restore Alluvial Aquifer by Natural Attenuation



Technical Task Cover Sheet							
Discipline H	ydrogeol	ogy	·····			Number of Sheets	
Project: MMTS							
Site: OU III Feasibility S	Study			7771			
Subject: Estimate groundwa vanadium PRGs are			l aquifer	following mill	site rem	ediation until the urani	um and
Sources of Data: 1) MMTS OU III RI g and vanadium trans						e FED17.VMF), and ui	ranium
Task Order No.		File 1	index No.				·
Proj. No.		Calc. No.	0073AA	Supersedes (Calc. No.		
Calculated by	Date	Checked by	Date	Approved by	Date	DOE Concurrence (if required)	Date
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U.S. Department of Energy Grand Junction Office

Problem Statement:

Estimate the volume of groundwater transmitted by the alluvial aquifer following millsite remediation until uranium and vanadium concentrations decrease to 30 pCi/L and 20 μ g/L, respectively.

Method of Solution:

Analytical solution based on numerical model results. Multiply groundwater flux across plane perpendicular to flow by the restoration periods for uranium and vanadium.

Computer Programs Used:

MODFLOW (groundwater flow model), VISUAL MODFLOW (MODFLOW pre- and post-processor), MT3D (solute transport model), GRAPHER (graphing program).

Assumptions:

- Groundwater flow is described by the OU III RI steady-state groundwater flow model (VISUAL MODFLOW flow model FED17.VMF).
- Groundwater flux across a plane perpendicular to groundwater flow at the eastern boundary
 of the millsite is representative of the entire aquifer. The uranium and vanadium plumes
 extend across the entire transect at this location as indicated in groundwater sample results.
 Groundwater flux at this location is 8,660 ft³/day (45 gal/min) per VISUAL MODFLOW
 water budget analysis.
- The U-234/238 restoration period (time required for concentrations to decrease to ≤30 pCi/L) is 60 yr considering all groundwater monitoring locations, per PA1 MT3D transport model UATT8 (refer to Calculation No. Q00069AA).
- The vanadium restoration period is >100 yr considering all monitoring locations, per MT3D transport model VATT3 (refer to Calculation No. Q00069AA). Transport simulations did not extend beyond 100 yr. Time/concentration results for wells 91–50 and 82–30B were graphically plotted and the linear portions of the curves were fitted by linear regression using the computer program GRAPHER (Figure A–1). Solving the equations resulted in restoration periods of 270 yr and 200 yr for well 91–50 and 82–30B, respectively. Several locations exhibit increasing vanadium concentrations during the transport simulations. For example, at well 91–03 (Figure A–2), located near the eastern boundary of the millsite, the maximum concentration occurs at 100 yr (250 μg/L) and therefore, a restoration period could not be extrapolated.

Results:

- The volume of water that will pass through the aquifer during the 60 yr period predicted for U-234/238 concentrations to decrease to 30 pCi/L or less is equal to 8,660 ft³/day × 60 yr × 365 day/yr = 1.9E+08 ft³.
- One pore volume of U-234/238 contaminated groundwater per Calculation No. Q00077AA is equal to 1.3E+07 ft³. Dividing the volume of water passing through the aquifer in 60 yr by the static pore volume equates to approximately 15 pore volumes of water to flush the aquifer of U-234/238 to 30 pCi/L or less.
- The volume of water that will pass through the aquifer during the 270 year period predicted for vanadium concentrations to decrease to 20 μg/L at well 91–50 is equal to 8,660 ft³/day × 270 yr x 365 day/yr = 8.5 × 10⁸ ft³. Assuming that the static pore volume of the vanadium plume is one-half of the uranium plume (by visual comparison), 130 pore volumes are required to flush the aquifer in the vicinity of well 91–50. Because maximum concentrations on the order of hundreds of μg/L are predicted at 100 years at some locations, the actual flushing volume may be greater.

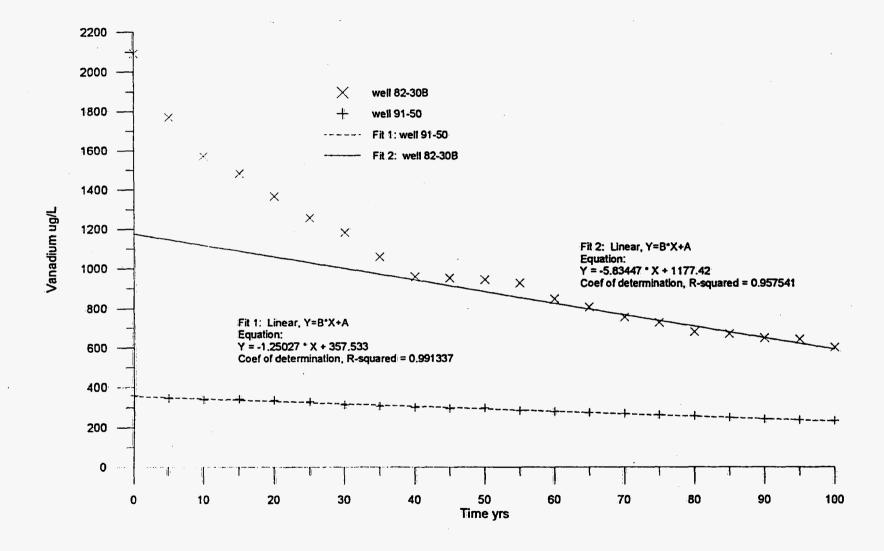


Figure A–1. Time/Concentration Results for Wells 82–30B and 91–50 modettc/norvz/vatt3.dat calc73.grl

Vanadium Attenuation No RVZ

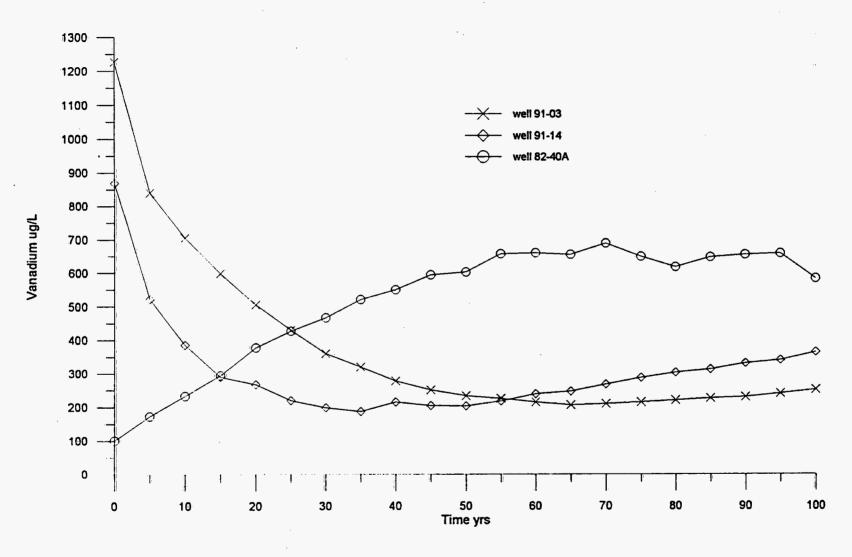


Figure A-2. Time/Concentration Results for Wells 91-03, 91-14, and 82-40A modeltc/vatt3.dat vatt3-5.grl

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Q00074AA

Model Results for Alternative 8A—Active Restoration

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Calculation No.: Q00074AA

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Discipline Hyd	drogeology		<u>.</u>		Number of Sheets	
Project: MMTS					,	
Site: OU III Feasibility Stu	udy					:
Subject: Estimate future COC Alternative 8A—Act		alluvial ground	lwater followin	g millsit	e remediation for FS	
Sources of Data: MMTS site characterization	on data was used t	o develop pred	ictive groundw	ater flow	v and solute transport n	nodels.
Task Order No. 3100 115 03 001		File Index No.				
Proj. No.	Caic. I	No. Q00074AA	Supersedes (-	Calc. No.		
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U.S. Department of Energy Grand Junction Office

Problem Statement:

Estimate future COC concentrations in groundwater at alluvial aquifer monitoring well locations following millsite remediation. Groundwater remediation is by active extraction at 21 locations, treatment, and injection of treated groundwater at 6 locations (Alternative 8A).

Method of Solution:

Numerical groundwater flow and solute transport modeling for arsenic, lead-210, manganese, radium-226, uranium, and vanadium.

Computer Programs Used:

MODFLOW (groundwater flow model), VISUAL MODFLOW (MODFLOW pre- and post-processor), MT3D (solute transport model).

Model Development/Assumptions:

- The OU III RI steady-state groundwater flow model was modified to include 21 extraction wells and 6 injection wells (VISUAL MODFLOW flow model PA8A3.VMF; see Figure A-1 for extraction and injection well locations).
- Extraction wells were placed at 16 millsite locations and 5 locations downgradient of the millsite coincident with areas of elevated COC concentrations in groundwater. The 21-well extraction rate was 38 gal/min.
- The 6-well injection rate was 25 gal/min. Injection wells were located to enhance aquifer flushing and prevent cells from drying in the eastern-most area of the millsite. The concentration of the injected water was specified at background values per COC.
- No model cell became dry as a result of groundwater extraction.
- Active remediation was simulated for 100 yr under steady-state flow conditions.
- Initial groundwater COC concentrations in the solute transport models are represented by interpolation of averaged COC concentrations at groundwater monitoring wells sampled during November 1992 to April 1996. Removal of dissolved solute via dewatering during millsite remediation is not represented in the models.
- The vadose zone of the remediated millsite is not a source of COCs to groundwater.
- Mill tailings presently beneath the water table are removed during millsite remediation.

• COC transport parameters were derived from the following OU III RI transport models: ASATT9 (arsenic), PBATT5 (lead-210), MNATT2 (manganese), RAATT5 (radium-226), UATT8 (U-234/238), and VATT3 (vanadium).

Results/Discussion:

Transport Model

- Tables A-1 through A-6 (attached) present COC concentrations for 100 yr at groundwater sampling wells assuming a 50-yr period of active restoration. Concentrations for the initial 50 yr are derived from Tables A-7 through A-12 (on-site and off-site active restoration). Concentrations for the final 50 yr are derived from the results of Alternative 1 (Tables A-13 through A-18) according to the methods described following Tables A-1 through A-6.
- Tabulated time/concentration results per groundwater sampling well are attached as
 Tables A-7 through A-12 for the following MT3D simulations: ASATT13 (arsenic),
 PBATT7 (lead-210), MNATT4 (manganese), RAATT9 (radium-226), UATT14 (U-234/238),
 and VATT7 (vanadium). Results of these simulations correspond to continuous aquifer
 restoration for 100 yr.
- Tabulated time/concentration results are attached as Tables A-13 through A-18 for Alternative 1 transport simulations ASATT9 (arsenic), PBATT5 (lead-210), MNATT2 (manganese), RAATT5 (radium-226), UATT8 (U-234/238), and VATT3 (vanadium). Results of these simulations represent 100 yr of passive restoration (Calculation No. Q00069AA).
- The accuracy of the manganese results is suspect among downgradient wells because of the large increases in concentration predicted during the initial 5 to 10 yr (e.g., well 88–85, Table A–14). Observed manganese concentrations at these locations are the result of approximately 45 yr of transport and therefore the predicted increases are considered unreasonable.
- In general, COC concentrations predicted at wells 82–13BEW, 91–55, and 91–58 are biased high as a result of an artifact of the transport model code. These wells are upgradient of all sources of contamination specified in the transport models and concentrations should therefore remain at approximately background levels. One exception occurs at well 91–55 in which high manganese concentrations are observed.
- Selenium concentrations (not modeled) do not presently exceed the regulatory standard (50 μg/L) at any well location downgradient of the millsite. On the millsite, selenium exceeds 50 μg/L only at well 91–35 (approximately 400 μg/L) and intermittently at well 91–23 (approximately 80 μg/L maximum). Each of these wells is located on the Acid Pile. Table A–19 (attached) presents estimated selenium concentrations at several millsite and downgradient wells for 25, 50, 75, and 100 years after millsite remediation. The estimates assume that the mobility of selenium in alluvial aquifer groundwater is equal to that of arsenic. Distribution coefficients (Kd) determined from Monticello results for arsenic and selenium were >80 mL/g and >110 mL/g, respectively. Description of the methods and other assumptions used to estimate selenium concentrations are provided in Table A–19.

Flow Model

- Groundwater extraction resulted in reversing a gaining stream condition to a losing stream condition in the western portion of the millsite. The pumping-induced flux from stream to aquifer (148 ft³/day) indicates that the stream (Montezuma Creek) is a minor source to the extraction wells in this area, which extract groundwater at a combined rate of 1,950 ft³/day.
- The net loss in stream flow due to groundwater extraction was 2,050 ft³/day. The difference between the well extraction and injection rates specified in flow model PA8A3 is 7,400 ft³/day 4,790 ft³/day = 2,610 ft³/day. This volume is available for discharge to the creek to compensate for the predicted stream loss.
- Other model flux boundaries were not significantly affected.
- Model cell flooding (groundwater elevation > ground surface elevation) did not occur as a result of injection at the specified rates.

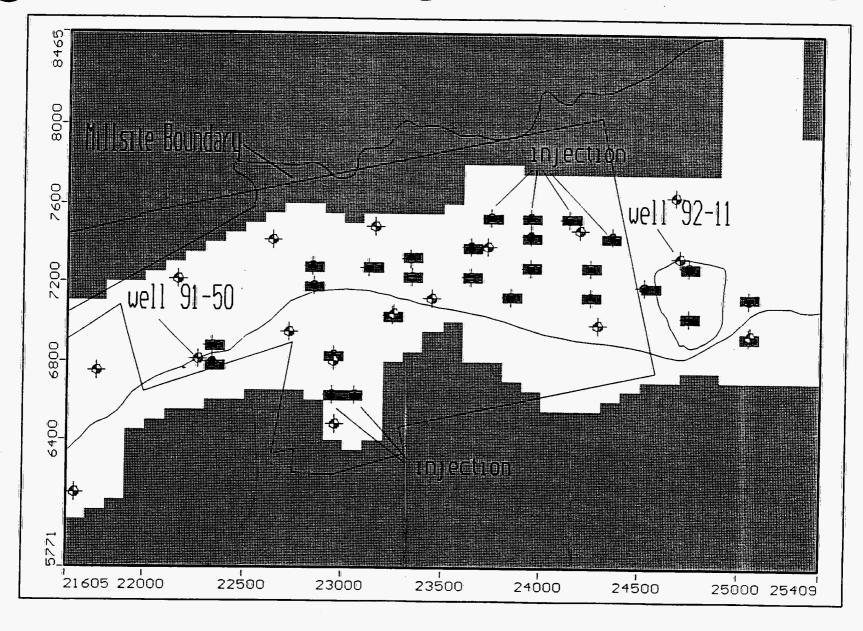
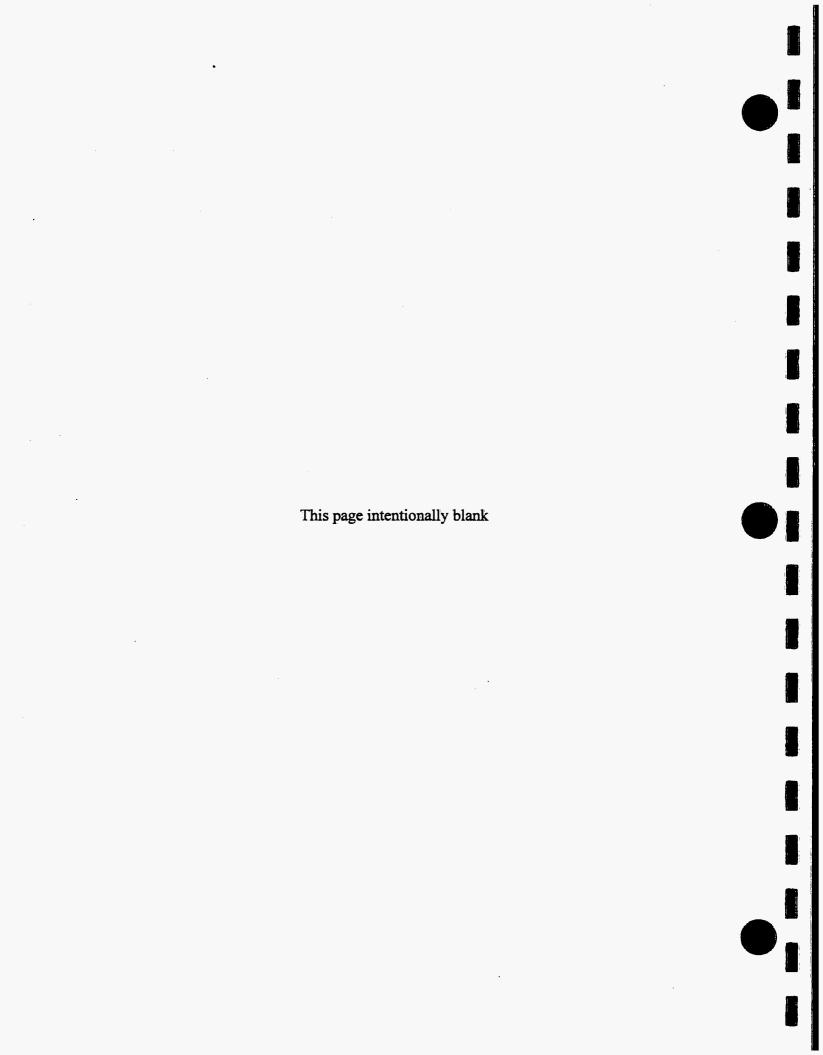


Figure A-1. Alternative 8A Well Locations

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Q00076AA

Initial Contaminant Mass in Aquifer



Calculation No.: Q00076AA

	Technical	Task	Cover Sh	<u>eet</u>			
Discipline Hydro	ogeology				Number of Sheets		
Project: MMTS		·					
Site: OU III Feasibility Stud	у						
Subject:							
Estimate present masse	s of dissolved and sorb	ed COCs	in alluvial aqu	ifer.			
Sources of Data:							
MMTS OU III RI numerica	l solute transport mode	l output.					
•							
Task Order No.	File l	Index No.					
Proj. No.		0076AA	Supersedes C	aic. No.			
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U.S. Department of Energy Grand Junction Office

Problem Statement:

Estimate present masses of dissolved and sorbed COCs in alluvial aquifer.

Method of Solution:

Mass budget analysis of initial concentrations specified in the numerical solute transport models. Each model cell is initially assigned a dissolved solute concentration interpolated from average concentrations at groundwater monitoring wells sampled during November 1992 to April 1996. The mass of dissolved and sorbed material within each model cell is calculated by MT3D (solute transport model) as a function of the dissolved concentration within each cell, the saturated thickness and porosity of the aquifer, and the solid:liquid partition coefficient. The sorbed mass and dissolved mass per COC was summed for each cell in the model domain in which the dissolved concentration was greater than or equal to the PRG.

Computer Programs Used:

MT3D (solute transport model). GETMASS (utility program used to analyze MT3D cell-by-cell output files). SURFER (contouring program).

Assumptions:

- SURFER interpolated dissolved COC concentrations specified as initial conditions in the solute transport represent actual site conditions.
- Solid:liquid partition coefficients specified in the OU III RI COC transport models are accurate.
- Alluvial aquifer saturated thickness and porosity are accurately represented in OU III RI groundwater flow model
- The mass of dissolved and sorbed solute is determined for all model cells in which the groundwater concentration exceeds the PRG of the COC.

Results:

See Table A-1 and the attached MT3D output (Table A-2 through A-7).

Table A-1. Estimate of Present Masses of Dissolved and Sorbed COCs in Alluvial Aquifer

coc	MT3D Model	Threshold Conc.	Dissolved Mass at Time = 0 ^a	Sorbed Mass at Time = 0 ^a
As	ASMASS2	50 μg/L	4.41E+09 μg	1.92E+11 µg
Pb-210	PBMASS2	2 pCi/L	2.07E+09 pCi	2.71E+10 pCi
Mn	MNMASS2	500 μg/L	7.37E+11 µg	6.40E+12 µg
Ra-226	RAMASS2	5 pCi/L	3.60E+08 pCi	7.82E+10 pCi
U-234/238	UMASS2	30 pCi/L	2.29E+11 pCi	9.94E+11 pCi
U-234/238	UMASS2	30 pCi/L	3.42E+11 μg ^b	1.48E+12 µgb
V	VMASS2	20 μg/L	8.10E+10 µg	1.76E+13 µg

^a MT3D output multiplied by 28.3 L/ft³ to convert volume units. ^b Converted MT3D output where 1 µg U-234/238 = 0.67 pCi U-234/238.

Table A-2. MT3D Output-Arsenic

Arsenic model ASMASS2. Time in days; mass as ug-ft3/L.
THE CELL-BY-CELL MASS FILE IS: asmass2.CBC
THE CONCENTRATION FILE IS: asmass2.CON
THE SELECTION CONDITION IS GE 50.000
ELAPSED TIME .0000 .0000
SOLUTE MASS .15591844E+09
SORBED MASS .67797793E+10
ELAPSED TIME 1825.0000 1825.0000
SOLUTE MASS .12720082E+09
SORBED MASS .55323193E+10
ELAPSED TIME 1825.0080 1825.0080

ELAPSED TIME 1825.0080 1825.0080 SOLUTE MASS .12720078E+09 SORBED MASS .55310552E+10 ELAPSED TIME 3649.9670 3649.9670 Lead-210 model PBMASS2. Time in days; mass as ug-ft3/L. THE CELL-BY-CELL MASS FILE IS: pbmass2.CBC THE CONCENTRATION FILE IS: pbmass2.CON THE SELECTION CONDITION IS GE 2.000 **ELAPSED TIME** .0000 .0000 SOLUTE MASS .73269962E+08 SORBED MASS .95659165E+09 ELAPSED TIME 1825.0000 1825.0000 SOLUTE MASS .64679007E+08 SORBED MASS .84451011E+09 ELAPSED TIME 1825.0080 1825.0080 SOLUTE MASS .64678981E+08 SORBED MASS .84443058E+09 ELAPSED TIME 3649,9670 3649,9670 SOLUTE MASS .57989558E+08

SORBED MASS .75713482E+09

Table A-4, MT3D Output-Manganese

Manganese model MNATT2. Time in days; mass as ug-ft3/L.

THE CELL-BY-CELL MASS FILE IS: mnmass2.CBC

THE CONCENTRATION FILE IS: mnmass2.CON

THE SELECTION CONDITION IS GE 500.000

ELAPSED TIME .0000 .0000

SOLUTE MASS .26026019E+11

SORBED MASS .22605457E+12

ELAPSED TIME 1825.0000 1825.0000

SOLUTE MASS .20769348E+11

SORBED MASS .18047915E+12

ELAPSED TIME 1825.0080 1825.0080

SOLUTE MASS .20770381E+11

SORBED MASS .18040117E+12

ELAPSED TIME 3649.9670 3649.9670

SOLUTE MASS .15469626E+11

SORBED MASS .13444831E+12

Radium-226 model RAMASS2. Time in days; mass as pCi-ft3/L. THE CELL-BY-CELL MASS FILE IS: ramass2.CBC THE CONCENTRATION FILE IS: ramass2.CON THE SELECTION CONDITION IS GE 5.000 .0000 .0000 **ELAPSED TIME** SOLUTE MASS .12713698E+08 SORBED MASS .27634496E+10 ELAPSED TIME 1825.0000 1825.0000 SOLUTE MASS .12035189E+08 SORBED MASS .26161574E+10 ELAPSED TIME 1825.0080 1825.0080 SOLUTE MASS .12035188E+08 SORBED MASS .26159689E+10 ELAPSED TIME 3649.9670 3649.9670 SOLUTE MASS .11122875E+08

SORBED MASS .24177992E+10

Table A-6. MT3D Output-Vanadium

Uranium model UMASS2. Time in days; mass as pCi-ft3/L.

THE CELL-BY-CELL MASS FILE IS: umass2.CBC

THE CONCENTRATION FILE IS: un

umass2.CON

THE SELECTION CONDITION IS GE 30.000

ELAPSED TIME .0000 .0000

SOLUTE MASS .80900208E+10

SORBED MASS .35133807E+11

ELAPSED TIME 1825.0000 1825.0000

SOLUTE MASS .50406150E+10

SORBED MASS .21893928E+11

ELAPSED TIME 1825.0080 1825.0080

SOLUTE MASS .50406096E+10 SORBED MASS .21890672E+11

ELAPSED TIME 3649.9670 3649.9670

SOLUTE MASS .31643617E+10

SORBED MASS .13744086E+11

Table A-7. MT3D Output-Uranium

Vanadium model VMASS2. Time in days; mass as ug-ft3/L. THE CELL-BY-CELL MASS FILE IS: vmass2.CBC THE CONCENTRATION FILE IS: vmass2.CON THE SELECTION CONDITION IS GE 20.000 **ELAPSED TIME** .0000 .0000 SOLUTE MASS .28638699E+10 SORBED MASS .62249082E+12 ELAPSED TIME 1825.0000 1825.0000 SOLUTE MASS .28396145E+10 SORBED MASS .61731712E+12 ELAPSED TIME 1825.0080 1825.0080 SOLUTE MASS .28396144E+10 SORBED MASS .61721865E+12 ELAPSED TIME 3649.9670 3649.9670 SOLUTE MASS .28163902E+10

SORBED MASS .61217278E+12

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Q00077AA

Volume of Water in Uranium Plume

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Calculation No.: Q00077AA

Technical Task Cover Sheet								
Discipline <u>H</u>	lydrogeo	logy				Number of Sheets		
Project: MMTS							:	
Site: OU III Feasibility	Study			-				
Subject: Estimate volume of	f alluvial	groundwater in w	hich U-2	34/238 exceed	s 30 pCi	/L.	· : :	
Sources of Data: 1) Ground water elevation data obtained during OU III RI. 2) Bedrock elevation data obtained during MMTS characterization. 3) Groundwater sample analytical results obtained during OU III RI.								
Task Order No.		File 1	ndex No.					
Proj. No.		Calc. No.	0077AA	Supersedes (Calc. No.			
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Problem Statement:

Estimate volume of alluvial aquifer groundwater in which U-234/238 exceeds 30 pCi/L.

Method of Solution:

Use SURFER volume calculation package to compute aquifer volume within 30 pCi/L U-234/238 contour and vertically bound by water table and upper bedrock surface, as follows: (1) Create SURFER blanking file defining the 30 pCi/L U-234/238 contour interpolated using SURFER from average concentrations at groundwater monitoring wells sampled during November 1992 to April 1996. U-234/238 plume contained in electronic format in file URAN5.GRD (SURFER grid file). (2) Create contour map of alluvial aquifer water table based on average groundwater elevations obtained from November 1992 to April 1996 observations (SURFER grid file AVWL.GRD). (3) Use blanking file to blank all groundwater elevation data of file AVWL.GRD outside of U-234/238 30 pCi/L contour. (4) Use SURFER volume calculator to compute the volume between the water table and bedrock surface of the resulting blanked groundwater elevation file (URANBLN.GRD). The bedrock surface is defined in SURFER grid file BEDELSR2.GRD, developed to represent the base of the alluvial aquifer in the site groundwater flow model. (4) Multiply the computed volume by the aquifer porosity (0.32).

Compute Programs Used:

SURFER (contouring program).

Assumptions:

Interpolated water table, bedrock surface, and U-234/238 concentrations are representative of actual conditions. Porosity estimate is representative of the entire alluvial aquifer.

Results:

SURFER volume calculation mean = 4.3E+07 ft³ (see Table A-1, SURFER output). SURFER volume calculation mean × aquifer porosity = 4.3E+07 ft³ × 0.32 = 1.3E+07 ft³. VOLUME COMPUTATIONS: CONVOL.TXT. All dimensions in feet.

UPPER SURFACE

Grid File: C:/WINSURF/OU3/REMSURF/URANBLN.GRD

Rows: 0 to 32766 Cols: 0 to 32766

Grid size as read: 489 cols by 99 rows

Delta X: 50 Delta Y: 49.7449

X-Range: 15200 to 39600 Y-Range: 4185 to 9060 Z-Range: 6720.52 to 6868.83

LOWER SURFACE

Grid File: R:/SHARE/EVERYONE/TRB/BEDELSR2.GRD

Rows: 0 to 32766 Cols: 0 to 32766

Grid size as read: 489 cols by 99 rows

Delta X: 50 Delta Y: 49.7449

X-Range: 15200 to 39600 Y-Range: 4185 to 9060 Z-Range: 6511.33 to 7180.71

VOLUMES

Approximated Volume by

Trapezoidal Rule: 4.25983E+007 Simpson's Rule: 4.27355E+007 Simpson's 3/8 Rule: 4.2569E+007

CUT & FILL VOLUMES

Positive Volume [Cuts]: 4.45786E+007 Negative Volume [Fills]: 1.98034E+006 Cuts minus Fills: 4.25983E+007

AREAS

Positive Planar Area

(Upper above Lower): 4.49902E+006

Negative Planar Area

(Lower above Upper): 466767

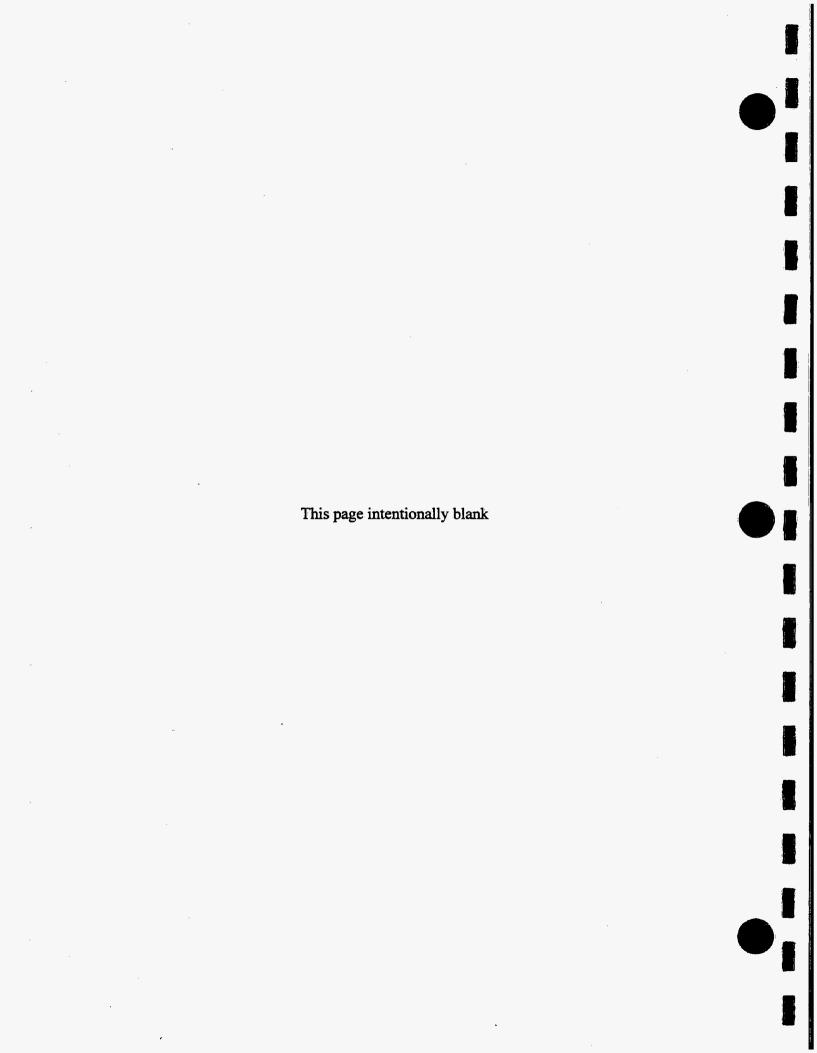
Blanked Planar Area: 1.13984E+008
Total Planar Area: 1.1895E+008

Positive Surface Area

(Upper above Lower): 4.50449E+006

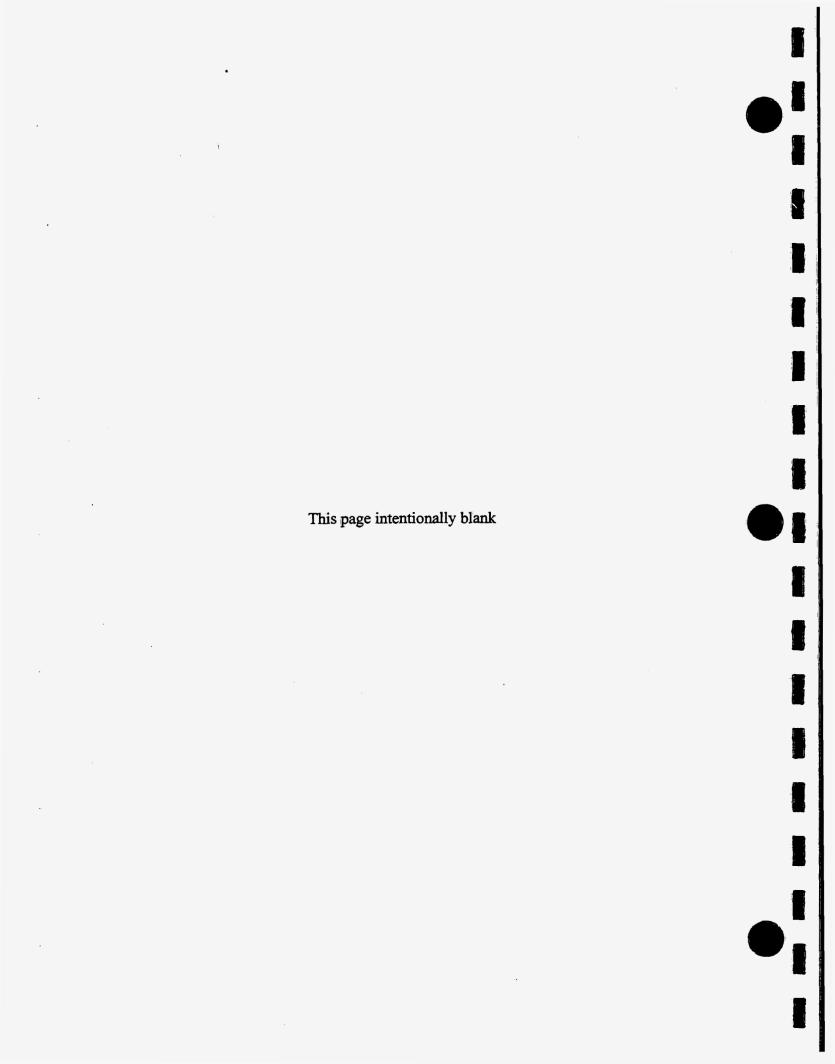
Negative Surface Area

(Lower above Upper): 467469



Q00078AA

Mass Removal and Treatment Volume—Alternatives 4, 7, 8A, and 8B



Calculation No.: Q00078AA

Technical Task Cover Sheet								
Discipline <u>H</u>	ydrogeo	logy				Number of Sheets		
Project: MMTS								
Site: OU III Feasibility S	tudy					,		
Subject:								
Estimate mass of Co 8A, and 8B.	OCs rem	noved from the allu	ıvial aqui	ifer and volume	e of wat	er treated for Alternati	ves 4, 7,	
Sources of Data:								
Volumetric water balance models.	ce result	s from groundwate	er flow m	odels and mass	s budget	results from solute tra	nsport	
Task Order No.		File I	index No.					
Proj. No.		Calc. No.	00078AA	Supersedes C	Calc. No.			
Calculated by	Date	Checked by	Date	Approved by	Date	DOE Concurrence (if required)	Date	
:								

U.S. Department of Energy Grand Junction Office

Problem Statement:

Estimate mass of COCs removed from the alluvial aquifer and volume of water treated for 4, 7, 8A and 8B.

Method of Solution:

- Alternative 4: The volume of groundwater treated at a given time is equivalent to the steady-state volumetric flux through the permeable segment of the treatment wall (gate) multiplied by time. The OU III RI steady-state groundwater flow model was modified to include an impermeable wall containing a permeable, reactive segment to remove COCs from groundwater (VISUAL MODFLOW flow model GATEWALL.VMF) as described in Calculation No. Q00071AA. VISUAL MODFLOW zone budget analysis indicates that steady-state flow through the gate is approximately 8,660 ft³/day (45 gal/min).
- Alternative 4: To estimate the mass removed from the aquifer, COC concentrations in the gate cells were first obtained from the following MT3D transport simulations at 5 yr increments: ASATT9 (arsenic), PBATT5 (lead-210), MNATT2 (manganese), RAATT5 (radium-226), UATT8 (U-234/238), and VATT3 (vanadium). These simulations represent passive aquifer restoration (refer to Calculation No. Q00071AA for transport model specifics). The 3-cell mean concentration was calculated, and for each 5-yr period, a concentration was then calculated as the mean of the beginning and ending concentrations per period to represent the groundwater concentration entering the treatment gate. The assumed concentration of gate effluent was then subtracted from the period mean to represent the concentration of COC to be removed during the period (see Table A-1 and A-2 for assumed effluent concentrations). The concentration removed at the gate was multiplied by the steady-state volumetric flux through the gate per 5-yr period to obtain the mass of COC removed. Cumulative water volume and COC mass removed was tabulated for each 5-yr period (see attached tables).
- Alternatives 7, 8A, and 8B: the volume of water removed by wells per alternative is
 equivalent to the combined steady-state extraction rate multiplied by the duration of pumping
 (see Tables A-3 through A-5) for flow models PA7B4, PA8A3, and PA8B, respectively.
 Refer to Calculation Nos. Q00072AA, Q00074AA, and Q00075AA, respectively, for flow
 model specifics.
- Alternatives 7, 8A, and 8B: the mass removed from the aquifer by wells is automatically computed by MT3D mass budget analysis and saved at user specified output times. The output times for PA8A and PA8B are 10, 25, 50, and 100 yr. The output times for PA7B are 10, 25, and 50 yr. See attached tables for mass of COCs removed by extraction wells. Refer to Calculation Nos. Q00072AA, Q00074AA, and Q00075AA, respectively, for transport model specifics.
- Each mass estimate is influenced by model specification of COCs at background values in uncontaminated regions of the model and in groundwater sources entering the model domain. Specified background concentrations are: 1.5 μg/L arsenic, 0.5 pCi/L lead-210, 30 μg/L

manganese, 0.2 pCi/L radium-226, 5.23 pCi/L U-234/238, and 2.8 μ g/L vanadium. These concentrations correspond to the means at groundwater monitoring wells located upgradient of the millsite and sampled during November 1992 to April 1996.

Computer Programs Used:

MODFLOW (groundwater flow model), VISUAL MODFLOW (MODFLOW pre- and post-processor), MT3D (solute transport model), LOTUS (spreadsheet program).

Table A-1. Alternative 4 Estimated COC Mass Treated and Volume of Groundwater Treated

PA4: ESTIMATED COC MASS TREATED AND VOLUME OF GROUNDWATER TREATED

- METHOD OF CALCULATION:
 1) ASSUME PERMEABLE TREATMENT GATE IN MODEL CELLS 2467, 2567, 2667.
- 2] COMPUTE MEAN CONCENTRATION IN GATE CELLS AT 5 YR INTERVALS PER PA1 TRANSPORT MODEL RESULTS.
- 3] MEAN CONCENTRATION THROUGH GATE PER 5 YR PERIOD EQUALS MEAN OF CONCENTRATIONS AT BEGINNING AND END OF 5 YR PERIOD.
- 4) SUBTRACT EFFLUENT CONC. FROM MEAN CONC.
- 5] MULTIPLY MEAN CONG. BY WATER FLUX THROUGH GATE PER 5 YR PERIOD = 8663 FT3/D.

Arsenic: assume effluent conc. = 5 ug/L

time y	r 0	5	10	15	20	25	30	35	40	45	:50
conc at gate	33.5	27.4	24.6	24.3	24.4	24.6	23.7	23	21.6	20.7	19.6 ug/L
conc minus eff conc	28.5	22.4	19.6	19.3	19:4	19.6	18.7	18	16.6	15.7	14.6 ug/L
period mean	na	25.5	21.0	19.5	19.4	19.5	19.2	18.4	17.3	16.2	15.2 ug/L
water flux	na	4.474E+08 Liter									
mass treated	na	1.139E+10	9.396E+09	8.702E+09	8.658E+09	8.725E+09	8.568E+09	8.210E+09	7.740E+09	7.226E+09	6.778E+09 ug
cum water flux	na	4.474E+08	8.948E+08	1.342E+09	1.790E+09	2.237E+09	2.685E+09	3.132E+09	3.579E+09	4.027E+09	4,474E+09 Litter
cum mass treated	na	1.139E+10	2.078E+10	2.949E+10	3.814E+10	4.687E+10	5.544E+10	6.365E+10	7_139E+10	7.861E+10	8.539E+10 ug
time y	r 50	55	60	65	70	75	-80	85	90	95	100
conc at gate:	19.6	18.8	17.9	16.9	16.4	15.6	14.9	13.9	13.7	13.2	12.5 ug/L
conc minus eff conc	14.6	13.8	12.9	11.9	11.4	10.6	9.9	8.9	8.7	8.2	7.5 ug/L
period mean	15.2	14.2	13.35	12.4	11.65	11	10.25	9.4	8.8	8.45	7.85 ug/L
water flux	4.474E+08	4.474E+08	4.474E+08	4:474E+08	4.474E+08 Liter						
mass treated	5.778E+09	6.353E+09	5.973E+09	5.548E+09	5.212E+09	4.922E+09	4.586E+09	4,206E+09	3.937E+09	3.781E+09	3.512E+09 ug
cum water flux	4.474E+09	4.922E+09	5.369E+09	5.816E+09	6.264E+09	6.711E+09	7.159E+09	7.606E+09	8.054E+09	8.501E+09	8.948E+09 Liter
cum mass treated	8:539E+10	9.174E+10	9.772E+10	1.033E+11	1.085E+11	1.134E+11	1.180E+11	1.222E+11	1.261E+11	1.299E+11	1.334E+11 ug

Uranium-234,238: assume effluent conc. = 30 pCi/L

		-									
time y	. 0	5	10	15	20	25		35	40	45	50
conc at gate	1442	588	220	117	75	53	42	32	26	22	18
conc minus eff conc	1412:0	558.0	190.0	87.0	45.0	23.0	12.0	2.0	-4.0	-8.0	-12.0 pCi/L
period mean	na	985.0	374.0	138.5	66.0	34.0	17.5	7.0	-1.0	-6.0	-10.0 pCVL
water flux	na	4.474E+08 Liter									
mass treated	na.	4.407E+11	1.673E+11	6.197E+10	2.953E+10	1.521E+10	7.830E+09	3.132E+09	0.000E+00	0.000E+00	0.000E+00 pCi
cum water:flux	na	4.474E+08	8.948E+08	1.342E+09	1.790E+09	2.237E+09	2.685E+09	3.132E+09	3.579E+09	4.027E+09	4:474E+09 Liter
cum mass treated	na	4.407E+11	6.080E+11	6.700E+11	6.995E+11	7.148E+11	7.226E+11	7.257E+11	7.257E+11	7.257E+11	7.257E+11 pCi
time v	50	55	60	65	70	75	80	85	90	95	100
conc at gate	18	15.8	14.3	12.7	11.6	10.7	9.8	9	8.4	8	7.5 pCVL
conc minus eff conc	-12.0	-14.2	-15.7	-17.3	-18.4	-19.3	-20.2	-21.0	-21.6	-22.0	
period mean	-10.0	-13.1	-15.0	-16.5	-17.9	-18.9	-19.8	-20.6	-21.3	-21.8	-22.3 pCi/L
water flux	4.474E+08	4.474E+08	4.474E+08	4.474E+08	4.474E+08	4.474E+08	4:474E+08	4.474E+08	4.474E+08	4.474E+08	4.474E+08 Liter
mass treated	0.000E+00 pCi										
cum water flux	4.474E+09	4.922E+09	5.369E+09	5.816E+09	6.264E+09	6.711E+09	7.159E+09	7:606E+09	8.054E+09	8.501E+09	8.948E+09 Liter
cum mass treated	7.257E+11 pCi										

Vanadium; assume effluent conc. ≈ 20 ug/L

time y	r 0.	5	10	15	20	25	30	35	40	45	50	
conc at gate	882	782	683	605	535	468	420	371	323	292	261	ug/L
conc minus eff conc	862	762	663	585	515	448	400	351	303	272	241	ug/L
period mean	na	812	712.5	624	550	481.5	424	375.5	327	287.5	256.5	ug/L
water flux:	∵ na	:4:474E+08	4.474E+08	Liter								
mass treated								1.680E+11				
cum water flux								3.132E+09				
cum mass treated	na	3.633E+11	6.821E+11	9.613E+11	1.207E+12	1.423E+12	1.613E+12	1.781E+12	1.927E+12	2.055E+12	2.170E+12	ug
time y	π 50	55	60	65	70	75	80	85	90	95	100	
conc at gate	261	238.6	221.5	210.3	202.8	197	197.4	195	197.6	198.7	205.6	ug/L
conc minus eff conc	241	218.6	201.5	190.3	182.8	177	177.4	175	177.6	178.7	185.6	ug/L
period mean	256.5	229.8	210.05	195.9	186.55	179.9	177.2	176.2	176.3	178.15	182.15	ug/L
water flux								4.474E+08				
mass treated								7.884E+10				
cum water flux	4.474E+09	4.922E+09	5.369E+09	5.816E+09	6.264E+09	6.711E+09	7.159E+09	7.606E+09	8:054E+09	8.501E+09	8.948E+09	Liter
cum mass treated	2.170E+12	2.273E+12	2.367E+12	2.455E+12	2.538E+12	2.619E+12	2.698E+12	2.777E+12	2.856E+12	2.935E+12	3.017E+12	ug.

Table A-1 (continued). Alternative 4 Estimated COC Mass Treated and Volume of Groundwater Treated

PA4: ESTIMATED COC MASS TREATED AND VOLUME OF GROUNDWATER TREATED

METHOD OF CALCULATION:

1] ASSUME PERMEABLE TREATMENT GATE IN MODEL CELLS 2457, 2557, 2657.

2] COMPUTE MEAN CONCENTRATION IN GATE CELLS AT 5 YR INTERVALS PER PA1 TRANSPORT MODEL RESULTS.

2] MEAN CONCENTRATION THROUGH GATE PER 5 YR PERIOD EQUALS MEAN OF CONCENTRATIONS AT BEGINNING AND END OF 5 YR PERIOD.

4] SUBTRACT EFFLUENT CONG. FROM MEAN CONG.

5] MULTIPLY MEAN CONC. BY WATER FLUX THROUGH GATE PER 5 YR PERIOD = 8663 FT3/D.

Manganese: assume effluent conc. = 500 ug/L

time y	r 0	5	10	15	20	25	30	35	40	45	50	
conc at gate	4570	3761	2313	1507	1042	744	541	395	306	242	191	ug/L
conc minus eff conc	4070	3261	1813	1007	542	244	41	-105	-194	-258		ug/L
period mean	na	3665.5	2537.0	1410.0	774.5	393.0	142.5	-32.0	-149,5	-226.0	-283.5	ug/L
water flux	· na	4.474E+08	Liter									
mass treated	na	1.640E+12	1,135E+12	6.309E+11	3.465E+11	1.758E+11	6.376E+10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	Ug:
cum water flux	na	4.474E+08	8.948E+08	1.342E+09	1.790E+09	2.237E+09	2.685E+09	3.132E+09	3.579E+09	4.027E+09	4.474E+09	Liter
cum mass treated	na	1.640E+12	2.775E+12	3.406E+12	3.753E+12	3.928E+12	3.992E+12	3.992E+12	3.992E+12	3.992E+12	3.992E+12	ug.
			00		70	70		85	00	0.0	400	
time y		55	•-	65	70	75			90	95	100	
conc at gate	191	157	130	110	96	84	76	70	63	60		ug/L
conc minus eff conc	-309	-343	-370	-390	-404	-416	-424	-430	-437	-440	-443	ug/L
period mean	-283.5	-326	-356.5	-380	-397	-410	-420	-427	-433.5	-438.5	-441.5	ug/L
water flux	4.474E+08	Liter										
mass treated	0.000E+00	0.000€+00	UC									
cum water flux	4.474E+09	4.922E+09	5.369E+09	5.816E+09	6.264E+09	6.711E+09	7.159E+09	7.606E+09	8.054E+09	8.501E+09	8.948E+09	Liter
cum mass treated	3.992E+12	ug										

Radium-226: assume effluent conc. = 0.5 pCl/L

time yr	. 0	-5	10	15	20	25	30	35	40	45	50	
conc at gate	1.91	1.76	1.44	1.3	1.31	1.37	1.45	1.53	1.66	1.71	1.85	PCVL
conc minus eff conc	1.41	1.26	0.94	0.8	0.81	0.87	0.95	1.03	1.16	1.21	1.35	PCIL
period mean.	กล	1.3	1.1	0.9	0.8	0.8	0.9	1.0	1.1	1.2	1.3	PCIL
water flux	na	4.474E+08	Liter									
mass treated	na	5.973E+08	4.922E+08	3.893E+08	3.602E+08	3.758E+08	4.072E+08	4.429E+08	4.899E+08	5.302E+08	5.727E+08	pCi
cum water flux	na	4.474E+08	8.948E+08	1.342E+09	1.790E+09	2.237E+09	2.685E+09	3.132E+09	3.579E+09	4.027E+09	4.474E+09	Liter
cum mass treated	กล	5.973E+08	1.089E+09	1.479E+09	1.839E+09	2.215E+09	2.622E+09	3.065E+09	3.555E+09	4.085E+09	4.658E+09	pCI
time y	r 50	55	60	65	70	75	80	85	90	.95	100	
conc at gate	1.85	1.94	2	2.05	2.08	2.15	2.17	2.14	2:14	2.17	2.09	DCVL
conc minus eff conc	1.35	1.44	1.5	1.55	1.58	1.65	1.67	1.64	1.64	1:67	1.59	
period mean	1.3	1.395	1,47	1.525	1.565	1.615	1.66	1.655	1,64	1,655	1.63	DCI/L
water flux	4.474E+08	Liter										
mass treated	5.727E+08	6.242E+08	6.577E+08	6.823E+08	7.002E+08	7.226E+08	7.427E+08	7.405E+08	7.338E+08	7.405E+08	7.293E+08	pCl
cum water flux	4.474E+09	4.922E+09	5.369E+09	5.816E+09	6.264E+09	6.711E+09	7.159E+09	7.606E+09	8.054E+09	8.501E+09	8.948E+09	Liter
cum mass treated	4.658E+09	5.282E+09	5.940E+09	6.622E+09	7.322E+09	8.045E+09	8.787E+09	9.528E+09	1.026E+10	1.100E+10	1.173E+10	pCI

Lead-210; assume effluent conc. = 1 pCVL

time y	r 0	5	10	15	20	25	30	35	40	45	50
conc at gate	10.2	7.85	5.85	4.79	4.42	4.01	3.62	3.14	2.72	2.39	2.1 pCVL
conciminus eff conci	9.2	6.85	4.85	3.79	3.42	3.01	2.62	2.14	1.72	1.39	1.1 pCVL
period mean	na	8.0	5.9	4.3	3.6	3.2	2.8	2.4	1.9	1.6	1.2 pCVL
water flux	na	4.474E+08 Liter									
mass treated	na	3.591E+09	2.617E+09	1.933E+09	1.613E+09	1.438E+09	1.259E+09	1.065E+09	8.635E+08	6.957E+08	5.570E+08 pCl
cum water flux	na	4.474E+08	8.948E+08	1.342E+09	1.790E+09	2.237E+09	2.685E+09	3.132E+09	3.579E+09	4.027E+09	4.474E+09 Liter
cum mass treated	na	3.591E+09	6.208E+09	8.141E+09	9.754E+09	1.119E+10	1.245E+10	1:352E+10	1.438E+10	1.508E+10	1.563E+10 pCi
time v	r 50	55	60	65	70	75	80	85	90	95	100
conc at gate	2.1	1.89	1.67	1.51	1.36	1.25		1.08		0.96	
conc minus eff conc	1.1	0.89	0.67	0.51	0.36	0.25	0.17	0.08	0.01	-0.04	-0.08 pCVL
period mean	1,2	0.995	0.78	0.59	0.435	0.305	0.21	0.125	0.045	-0.015	-0.06 pCI/L
water flux	4:474E+08	4.474E+08 Liter									
mass treated	5.570E+08	4.452E+08	3.490E+08	2.640E+08	1.946E+08	1.365E+08	9.396E+07	5.593E+07	2.013E+07	0:000E+00	0.000E+00 pCi
cum water flux	4.474E+09	4.922E+09	5.369E+09	5.816E+09	6.264E+09	6.711E+09	7.159E+09	7.606E+09	8.054E+09	8.501E+09	8.948E+09 Liter
cum mass treated	1.563E+10	1.508E+10	1.643E+10	1.669E+10	1.689E+10	1.702E+10	1.712E+10	1.717E+10	1.719E+10	1.719E+10	1.719E+10 pCl

Table A-2. Alternative 7 Estimated COC Mass Removal and Volume of Groundwater Extracted

PA7B MASS REMOVED BY WELLS AT TIME = 10 YR VOLUME OF WATER REMOVED BY WELLS = 3.01E+07 FT3 FLOW MODEL PA7B4

	MT3D	WELLS OUT	
	WELLS OUT	CONVERTED	MT3D FILE
ARSENIC	1.156E+09 UG-FT3/L	3.271E+10 UG	ASATT23
URAN	1.232E+10 PCI-FT3/L	3.488E+11 PCI	UATT23
VANAD	1.287E+10 UG-FT3/L	3.642E+11 UG	VATT15
MANGAN	7.611E+10 UG-FT3/L	2.154E+12 UG	MNATT10
PB210	2.432E+08 PCI-FT3/L	6.882E+09 PCI	PBATT13
RA226	1.605E+08 PCI-FT3/L	4.543E+09 PCI	RAATT15

PA7B MASS REMOVED BY WELLS AT TIME = 25 YR VOLUME OF WATER REMOVED BY WELLS = 7.53E+07 FT3 FLOW MODEL PA7B4

	MT3D	WELLS OUT	
	WELLS OUT	CONVERTED	MT3D FILE
ARSENIC	2.249E+09 UG-FT3/L	6.365E+10 UG	ASATT23
URAN	1.436E+10 PCI-FT3/L	4.065E+11 PCI	UATT23
VANAD	2.844E+10 UG-FT3/L	8.049E+11 UG	VATT15
MANGAN	1.044E+11 UG-FT3/L	2.953E+12 UG	MNATT10
PB210	3.868E+08 PCI-FT3/L	1.095E+10 PCI	PBATT13
RA226	3.464E+08 PCI-FT3/L	9.804E+09 PCI	RAATT15

PA7B MASS REMOVED BY WELLS AT TIME = 50 YR VOLUME OF WATER REMOVED BY WELLS =1.51E+08 FT3 FLOW MODEL PA7B4

	MT3D	WELLS OUT	
	WELLS OUT	CONVERTED	MT3D FILE
ARSENIC	3.473E+09 UG-FT3/L	9.828E+10 UG	ASATT23
URAN	1.538E+10 PCI-FT3/L	4.353E+11 PCI	UATT23
VANAD	5.033E+10 UG-FT3/L	1.424E+12 UG	VATT15
MANGAN	1.166E+11 UG-FT3/L	3.299E+12 UG	MNATT10
PB210	5.046E+08 PCI-FT3/L	1.428E+10 PCI	PBATT13
RA226	5.747E+08 PCI-FT3/L	1.627E+10 PCI	RAATT15

Table A-3. Alternative 8A Estimated COC Mass Removed and Volume of Groundwater Extracted

PA8A MASS REMOVED BY WELLS AT TIME = 10 YR VOLUME OF WATER REMOVED BY WELLS = 2.70E+07 FT3 FLOW MODEL PA8A3

	MT3D	WELLS OUT	
	WELLS OUT	CONVERTED	MT3D FILE
ARSENIC	9.631E+08 UG-FT3/L	2.726E+10 UG	ASATT13
URAN	1.203E+10 PCI-FT3/L	3.404E+11 PCI	UATT14
VANAD	1.281E+10 UG-FT3/L	3.624E+11 UG	VATT7
MANGAN	6.720E+10 UG-FT3/L	1.902E+12 UG	MNATT4
PB210	2.118E+08 PCI-FT3/L	5.993E+09 PCI	PBATT7
RA226	1.050E+08 PCI-FT3/L	2.972E+09 PCI	RAATT9

PA8A MASS REMOVED BY WELLS AT TIME = 25 YR VOLUME OF WATER REMOVED BY WELLS = 6.75E+07 FT3 FLOW MODEL PA8A3

	MT3D	WELLS OUT	
	WELLS OUT	CONVERTED	MT3D FILE
ARSENIC	2.002E+09 UG-FT3/L	5.666E+10 UG	ASATT13
URAN	1.424E+10 PCI-FT3/L	4.030E+11 PCI	UATT14
VANAD	2.913E+10 UG-FT3/L	8.242E+11 UG	VATT7
MANGAN	9.619E+10 UG-FT3/L	2.722E+12 UG	MNATT4
PB210	3.709E+08 PCI-FT3/L	1.050E+10 PCI	PBATT7
RA226	2.478E+08 PCI-FT3/L	7.012E+09 PCI	RAATT9

PA8A MASS REMOVED BY WELLS AT TIME = 50 YR VOLUME OF WATER REMOVED BY WELLS = 1.35E+08 FT3 FLOW MODEL PA8A3

	MT3D		WELLS OUT	
	WELLS OUT		CONVERTED	MT3D FILE
ARSENIC	3.209E+09	UG-FT3/L	9.082E+10 UG	ASATT13
URAN	1.526E+10	PCI-FT3/L	4.319E+11 PCI	UATT14
VANAD	5.207E+10	UG-FT3/L	1.474E+12 UG	VATT7
MANGAN	1.093E+11	UG-FT3/L	3.093E+12 UG	MNATT4
PB210	5.022E+08	PCI-FT3/L	1.421E+10 PCI	PBATT7
RA226	4.538E+08	PCI-FT3/L	1.284E+10 PCI	RAATT9
PB210	5.022E+08	PCI-FT3/L	1.421E+10 PCI	PBATT

PA8A MASS REMOVED BY WELLS AT TIME = 100 YR VOLUME OF WATER REMOVED BY WELLS = 2.7E+08 FT3 FLOW MODEL PA8A3

	MT3D	WELLS OUT	
	WELLS OUT	CONVERTED	MT3D FILE
ARSENIC	4.679E+09 UG-FT3/L	1.324E+11 UG	ASATT13
URAN	1.618E+10 PCI-FT3/L	4.578E+11 PCI	UATT14
VANAD	8.922E+10 UG-FT3/L	2.525E+12 UG	VATT7
MANGAN	1.170E+11 UG-FT3/L	3.312E+12 UG	MNATT4
PB210	6.212E+08 PCI-FT3/L	1.758E+10 PCI	PBATT7
RA226	7.786E+08 PCI-FT3/L	2.204E+10 PCI	RAATT9

Table A-4. Alternative 8B Estimated COC Mass Removed and Volume of Groundwater Extracted

PA8B MASS REMOVED BY WELLS AT TIME = 10 YR VOLUME OF WATER REMOVED BY WELLS = 5.06E+07 FT3 FLOW MODEL PA8B

•	MT3D	WELLS OUT	
	WELLS OUT	CONVERTED	MT3D FILE
ARSENIC	1.148E+09 UG-FT3/L	3.249E+10 UG	ASATT17
URAN	1.750E+10 PCI-FT3/L	4.952E+11 PCI	UATT18
VANAD	1.682E+10 UG-FT3/L	4.761E+11 UG	VATT11
MANGAN	9.185E+10 UG-FT3/L	2.599E+12 UG	MNATT5
PB210	2.660E+08 PCI-FT3/L	7.529E+09 PCI	PBATT8
RA226	1.154E+08 PCI-FT3/L	3.266E+09 PCI	RAATT10

PA8B MASS REMOVED BY WELLS AT TIME = 25 YR VOLUME OF WATER REMOVED BY WELLS = 1.26E+09 FT3 FLOW MODEL PA8B

	MT3D	WELLS OUT	
	WELLS OUT	CONVERTED	MT3D FILE
ARSENIC	2.439E+09 UG-FT3/L	6.902E+10 UG	ASATT17
URAN	2.091E+10 PCI-FT3/L	5.919E+11 PCI	UATT18
VANAD	3.923E+10 UG-FT3/L	1.110E+12 UG	VATT11
MANGAN	1.349E+11 UG-FT3/L	3.818E+12 UG	MNATT5
PB210	4.758E+08 PCI-FT3/L	1.346E+10 PCI	PBATT8
RA226	2.763E+08 PCI-FT3/L	7.819E+09 PCI	RAATT10

PA8B MASS REMOVED BY WELLS AT TIME = 50 YR VOLUME OF WATER REMOVED BY WELLS = 2.53E+09 FT3 FLOW MODEL PA8B

	MT3D	WELLS OUT	
	WELLS OUT	CONVERTED	MT3D FILE
ARSENIC	3.996E+09 UG-FT3/L	1.131E+11 UG	ASATT17
URAN	2.251E+10 PCI-FT3/L	6.371E+11 PCI	UATT18
VANAD	7.122E+10 UG-FT3/L	2.016E+12 UG	VATT11
MANGAN	1.544E+11 UG-FT3/L	4.369E+12 UG	MNATT5
PB210	6.624E+08 PCI-FT3/L	1.875E+10 PCI	PBATT8
RA226	5 136E+08 PCI-FT3/L	1.453E+10 PCI	RAATT10

PA8B MASS REMOVED BY WELLS AT TIME = 100 YR VOLUME OF WATER REMOVED = 5.06E+09 FT3 FLOW MODEL PA8B

1 COTT MODEL THOS				
	MT3D	WELLS OUT		
	WELLS OUT	CONVERTED	MT3D FILE	
ARSENIC	5.973E+09 UG-FT3/L	1.690E+11 UG	ASATT17	
URAN	2.412E+10 PCI-FT3/L	6.825E+11 PCI	UATT18	
VANAD	1.220E+11 UG-FT3/L	3.452E+12 UG	VATT11	
MANGAN	1.669E+11 UG-FT3/L	4.722E+12 UG	MNATT5	
PB210	8.537E+08 PCI-FT3/L	2.416E+10 PCI	PBATT8	
RA226	9.011E+08 PCI-FT3/L	2.550E+10 PCI	RAATT10	